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New York Meeting of the American Electrochemical Society.

New York, as a convention city, is a somewhat dangerous place, as experience has shown that while it is easy to get a good attendance on paper in form of a long registry list, yet it is difficult to hold the members together for any length of time. No such difficulty was experienced at the recent convention of the American Electrochemical Society and this fact is conclusive evidence that those who attended it came with a purpose and that the society at its meetings gives to its members what they want and need. It was interesting to analyze the personnel of the attendance. There were those typical electrochemists—many of them from Niagara—who have attended practically every meeting of the Society from the beginning. But the nucleus has grown. The new recruits have come both from the chemical and metallurgical fields. Pittsburgh alone, for instance, has sent large and enthusiastic delegations to every one of the last meetings. The circle is larger, but the esprit de corps is the same as in olden times. The growth of the Society reflects accurately the growth of the industry.

Simple Tin Reduction.

In searching the rather meager literature on the metallurgy of tin one is struck by the lack of definite information which would enable a metallurgist ordinarily skilled in his profession to undertake the reduction of tin ore with reasonable prospect of success. In a general way it is understood that both shaft and reverberatory furnaces have been used, but regarding the details of smelting mixtures and compositions of slags contributors generally are silent. Two queries arise in this connection. Is it to be inferred that the reduction of tin is a complex metallurgical process evolved by the highest technical skill and hence held as a trade secret? Or are the conditions of success so variable according to local conditions that the principles of the process are not reducible to terms for general guidance? Perhaps the truth lies partly in the answer to both questions.

Undoubtedly the impurity of some tin ores, contaminated as they are with bismuth, tungsten, arsenic, iron, copper and zinc, has been responsible for the seeming complexity of their treatment. Roasting, leaching and concentrating are preliminary processes in many instances; and the smelting and re-smelting of slags, liquating and poling of the reduced tin, and retreatment of impure residues, comprise accessory processes which give an aspect of complexity to the work. Finally, the production of grades of tin of varying purity testifies to the difficulty of securing a uniformly pure product.

It is rather refreshing, therefore, to find that the recent reduction of tin ore in Texas is characterized by simplicity which is in striking contrast to the complex procedure mentioned. True, natural conditions are favorable in that the

cassiterite is quite pure; nevertheless, those in charge of the work were obliged to put their own ideas into practice, despite the predictions of failure from foreign sources. Their success was striking. By mixing the fine tin concentrate with 8 per cent to 12 per cent fine anthracite coal, heating and rabbling the mixture on the hearth of an oil-burning reverberatory furnace, the tin was reduced in a pure condition, 99.8 per cent and 99.9 per cent fine, ready for market. No slag-forming ingredients were added, and no slag made; nor was it necessary subsequent to refine the tin by liquation or by poling with green wood. Later we shall have more detailed information to present regarding this interesting work.

The Pachuca Agitator.

A note of striking unanimity was sounded by all cyanide experts in their annual reviews for 1910 in regard to the use of the Brown or Pachuca tank for agitation. Almost with one accord they hailed it as the best machine for agitating ore pulp in cyanide solution, and recorded its triumphant path through the goldfields of the world. Apparently the only objection which had been raised to the Pachuca tank, viz., its height and the consequent head-room required, was regarded as having been removed by the system of continuous treatment adopted by Grothe and Kuryla. And yet if the literature be searched for information regarding the agitator little will be found except the usual description embodying dimensions, time required and results obtained. All of which suggests that perhaps the Pachuca tank has been accepted at sight, without being subjected to the exhaustive inquiry usually directed toward kindred devices.

It is not surprising, therefore, that recently some investigations have been made regarding the height of the tank, and whether such height is necessary to accomplish to best advantage the primary purpose of the machine, viz., solution of the precious metals. In ordinary practice the central air-lift extends practically the full height of the tank, and pulp and air are discharged at the top, the former settling for further agitation and the latter escaping into the air. The question arises whether, considering the great height of the tank, 45 ft., it offers the fullest opportunity for dissolution of the values throughout the cycle of operations. Aeration is probably effective only in the central column, and at the top of the charge, while dissolution may not be effective in the return downward path of the pulp.

Several experiments apparently have proved that the air-lift should discharge considerably below the surface of the charge in order that better aeration and dissolution may occur. Philip Argall has modified standard practice at Cripple Creek by shortening the central pipe so that the pulp is discharged 8 or 10 in. below the surface of the charge, thus spreading the air through the upper portion of the charge, and improving aeration and dissolution. A. J. Yaeger has gone further. At the Zambona Development Company, Mexico, the tank has been modified until now the central air-lift is but half the height of the tank, and the discharging air rises in small bubbles through the upper half of the charge, materially improving agitation and increasing extraction as compared with former practice.

As stated above, the main object of the tank is to secure solution of one or two of the elements in the mixture. The physical conditions governing rapid solution require that fresh surfaces of the substance to be dissolved be continuously exposed to the solvent, either by changing the position of the substance in the solvent, or allowing the latter to flow over it, or both. A. W. Warwick has suggested that these conditions are not fulfilled in the great mass of pulp falling in the tank outside the central air-lift, and that the machine is consequently inefficient, considering its great height and volume. Granting that agitation and aeration occur in the central air-lift and at the surface of the charge, may it not be probable that on settling the particles of ore and the solution fall at too nearly the same rate of speed to provide the best conditions for solution.

The Pachuca tank is unquestionably a success, but perhaps the chemist has accepted the dictum of the mechanical engineer without due inquiry, and we may look for material improvement as the former makes more thorough investigation.

Steel Production in 1910.

Official statistics show the production of steel ingots and castings in the United States in 1910 to have been as follows, in gross tons:

Bessemer (acid)	9,412,772
Basic open-hearth	15,292,329
Acid open-hearth	1,212,180
Total open-hearth	16,504,509
Crucible	122,303
Electric	52,141
Miscellaneous	3,194
Total, all steel	26,094,919

There is a gain in the total over 1909 of 2,139,898 tons and of 2,700,000 tons over 1906 and 1907, the two best previous years, 1909 having been an "off" year with an output of only 14,023,247 tons.

The total in 1910 comprised 940,832 tons of castings and 25,154,087 tons of ingots. Statistics of rolled steel in 1910 will hardly be completed until late in the year. In 1906, 1907 and 1909 the rolled steel was about 22.5 per cent less than the tonnage of ingots, this representing in small part the unavoidable losses of material, but in large part scrap produced in rolling and which was promptly returned to the Bessemer vessel or open-hearth furnace, chiefly the latter, to be remelted, the same steel thus passing again over the ingot scales. What is customarily given as the "production of steel" is really the record of the ingot scales. The production of steel is more properly the production of rolled steel, weighed after its last hot rolling and after it has been cropped. Applying the 22.5 per cent just derived the production of rolled steel in 1910 promises to be about 19,600,000 tons. We may anticipate a little by observing that in 1909 the production of rolled iron amounted to 1,709,431 tons, so that the total production of rolled iron and steel in 1910 promises to be in the neighborhood of 21,000,000, or 21,500,000 gross tons. In addition we have the 940,832 tons of steel castings, while the iron foundries probably produced not far from 10,000,000 tons of iron castings. The total doubtless exceeds 30,000,000 tons, comparing with 27,298,545 tons of pig iron produced in the year. There is, of course, a large utilization of scrap, by steel works, iron

mills and foundries. A small part of the rolled steel is old material rerolled, the chief products being light rails, bedstead angles and concrete reinforcing bars.

The basic open-hearth steel industry has taken chief rank in our steel processes so suddenly that there is little to say from a statistical standpoint. In 1907 the total open-hearth steel production fell just short of the Bessemer, with 1,270,421 tons of the open-hearth steel made by the acid process; in 1908 the basic open-hearth steel alone exceeded the Bessemer output, but both processes fell far short of equalling their previous records; in 1909 basic open-hearth steel showed a much larger tonnage than Bessemer and acid open-hearth combined, these being the two processes which use pig iron and scrap of limited phosphorus content. In 1910 the production by the basic open-hearth process exceeded that of the Bessemer process by 62 per cent. There is no prospect of the Bessemer process ever equalling its record output, made with 12,275,830 tons in 1906. Since that year no new Bessemer plants have been built, while one efficient plant has been dismantled and another has been turned largely to the practice of the duplex process. How far the electric refining furnace as an accessory to the converter will be able to change the situation it is too early yet to surmise. That the electric furnace will become of decisive importance, however, in this respect, there can be no doubt.

Efficiency and Conservation.

Much has been written of late in both technical and popular magazines on the subject of efficiency and scientific management. It is a rather remarkable fact that although the principles of efficiency engineering are scientific in the highest degree, yet their application has been largely in the field of industry rather than of science. The tradesman, mechanic and factory hand have been its beneficiaries, while the strictly scientific worker has either been purposely neglected or considered able to direct his own efforts to attain the highest degree of efficiency. There may be a subtle compliment in this neglect of the scientist, and if so, fact and conditions ought to show him worthy of it, but we suspect that investigation will find him a transgressor in many simple and almost inexcusable ways.

Efficiency implies system; system implies knowledge of details, and this, in turn, implies brains. We thus come to brains, or a central competent head, as the foremost requirement of efficient work in a laboratory, smelter or plant. Next in point of importance comes the individual ability of the man for his task, and the collective efficiency of the entire corps of men engaged in work to a common end. Finally, the correct design of the plant, the construction of the various buildings, and means for accomplishing the necessary work, form a vital element in the whole system of efficient operation. Given these conditions we have operative conservation in its truest form, as far as it relates to time, money, material and energy.

The directing head of a chemical or metallurgical plant should have more knowledge of the work in hand than any of those under him. This may seem a self-evident proposition, but the instances have been known, especially in the early history of metallurgy in the West, where the smelter boss and the political boss were one and the same, and where technical positions were granted for some real or fancied service in another

sphere of activity. Under such conditions metallurgical efficiency and conservation were at a low ebb, and financial success ensued only because the property could stand mismanagement. Those in charge were incompetent to initiate improvements, or pass competently on the suggestions of their employees, many of whom were far superior in technical skill and ability, but without authority to enforce their views.

On the second point—individual fitness and the collective ability of the entire corps—an inquiry often will reveal weak points which do not appear on the surface. We can recall cases where excellent laboratory chemists apparently failed when placed outside, and again where men seemingly poorly adapted to the work of the laboratory made successes in the plant. It is the old problem of the square peg and the round hole, and presents a condition where both individual efficiency and the general efficiency of the plant would be higher if the men were kept where they could work best. The routine work of the laboratory, made up as it is of a few separate operations, each repeated many times during the day, requires a certain temperament for its best performance, and the man who can do it well may not be able to direct those larger operations in the plant which consist in the handling of labor and material, and the economical output of the product.

On the third score, viz., correct design and construction of plant, we find many transgressions of the laws of efficiency and conservation. Perhaps nothing has been so potent in the development of chemical and metallurgical engineering as a profession as the mere fact that those on whom the chemist or metallurgist formerly relied for design and construction of plants, did not fully understand the technical requirements of the plant as a whole, and hence failed to produce the best result. The chemical and metallurgical engineer was a logical development in the demand for efficiency in plant construction. The design and construction of a plant, of the individual buildings, and their grouping together, all exert a wonderful influence on general efficiency. Poor arrangement will nullify the benefits gained through a trained corps of workmen, and illogical design will defeat the ends of the best appliances. A workman, consciously or unconsciously, will neglect a machine placed in an inconvenient place. He will not inspect those parts of the plant which are difficult of access, or which are uncomfortable to visit, with the same regularity or willingness that he will perform the more agreeable part of his duties. Hence the necessity for construction and arrangement which, per se, will not constitute a cause for neglect of duty.

Poor arrangement of laboratory or plant will cause many unnecessary steps to be taken and useless time consumed in transporting material from one part to another. The cost of these wastes of time and energy will amount to a considerable sum per annum, and frequently they will not be appreciated until an investigation has shown where loss can be changed to profit. Fortunately, as said before, the chemical and metallurgical engineer is taking care of these matters as never before in the history of the industry. Much is required of him. He must have mental ability and physical capacity; executive as well as engineering training, and business sense of a high order. With these qualities he will not be guilty of making avoidable wastes and recoverable losses, and will give high efficiency and genuine conservation in all his work.

Notes on Chemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)
Electric Furnaces and Heating.

In the course of the second Cantor Lecture, recently delivered before the Society of Arts, Dr. J. A. Fleming said that the methods of electric heating were classified into resistance heating, arc heating and combinations of the two. He mentioned Sir William Siemens' early experiments on the electrical fusion of steel in 1879, and described the electric-arc furnaces of E. Stassano and Paul Héroult in 1898 and 1899. Héroult in 1900 manufactured steel from pig iron and scrap by means of his arc-resistance furnace; and furnaces were at La Praz now producing six or more tons of steel a day, at an expenditure of 800 to 900 kw-hours per ton. Pig iron could be prepared electrically from hematite by an expenditure of about 2,000 to 2,200 kw-hours per metric ton. The modern blast furnace used only about 16 cwt. of coke per ton of pig, of which 6.5 were required to reduce the ore, and the cost of electric energy must be reduced to 0.1 cent per kw-hour before the electric smelting could compete with the blast furnace. Electric furnaces, however, worked efficiently in the production of high-grade steel from scrap iron and pig in the place of, or as supplementing, the open-hearth process. The Girod arc furnace as developed by M. Paul Girod and used at his works at Ugines produced a high-class steel from scrap iron by an expenditure of 1,000 to 1,100 kw-hours per metric ton. The danger of carbon contamination by the arc furnace electrodes led to the invention of the Ferranti induction furnace, in which a large alternating-current transformer had a secondary circuit consisting of an endless channel lined with magnesite or dolomite, in which the metal was melted by induced currents. The Kjellin furnaces at Gysinge produced excellent steel from pig iron and scrap, consuming about 900 kw-hours per ton of steel; electric energy costing about 0.09d per kw-hour, or £2 per electrical hp-year. In combination furnaces, in addition to the heating of the charge by the induced currents, current induced in a copper secondary circuit was led through the charge from metal electrodes embedded in the furnace lining. The power factor was raised and the combination furnace could be worked at a higher frequency and by three-phase currents. Moreover, this furnace had a roomy and accessible hearth, and was excellent for refining. By using a basic lining sulphur and phosphorus could be eliminated and the occluded gases entirely removed, while the metal was not oxidized as in open-hearth furnaces. Another advantage was the economy of labor compared with the ordinary crucible processes. The electric furnace produced a high class of steel equal to the best crucible steel, and was especially adapted to the production of alloy steels, viz., vanadium, chrome and tungsten steels.

A 10,000-Volt Battery.

Mr. A. A. Campbell Swinton, at a meeting of the Röntgen Society, described a battery consisting of 4800 cells, a number which divided up into convenient sections of 80 cells for charging in parallel off a 200-volt supply. Arranged in series, it gave 10,400 volts on open circuit. Each cell consisted of a glass test tube 4 in. long and $\frac{3}{4}$ in. bore, and each set of 40 cells was cast solid with paraffin wax into a wooden tray. The battery was of the Planté type, and the plates were made of sheet lead cut into strips which were bent round a shaped piece of wood and pressed to a corrugated form not very liable to deformation. The plates were kept from touching each other by celluloid separators, and were all formed in a nursery battery before being transferred to the battery proper. The total weight of lead in the whole battery was 400 lb., and the total weight of the whole of the battery, exclusive of containing cases, was nearly 1000 lb.

To avoid bubbling the battery was charged at a rate not exceeding 10 milliamperes, and it was capable of discharging at

a rate of 150 milliamperes, giving $1\frac{1}{2}$ kw for several minutes. The internal resistance varied between 3000 and 4000 ohms.

With 10,000 volts between polished brass balls 12.5 mm in diameter the current was found to jump 2.5 mm, and the arc could be drawn out to a considerable length, dependent on the resistance in the circuit. That the current was often not entirely continuous was indicated by the arc making a whistling sound. A Leyden jar connected across the arc immediately converted it into a series of discontinuous sparks which, if the jar was of small capacity, followed one another very rapidly, producing a musical note which deepened into a roar when the capacity was increased. The battery showed very plainly the electro-capillary effect discovered by the late Lord Armstrong. At 8000 to 10,000 volts and about 5 milliamperes, and using pure water, the results were exactly similar to those obtained by him with hydroelectric and induction-coil discharges. The addition of a very small quantity of dilute sulphuric acid to the water, which destroyed all movement of the thread when induction-coil discharges were employed, was found, with the battery current, not entirely to stop the thread moving, but increased the flow of water in the opposite direction. Practically all the Crookes and other vacuum-tube effects could be obtained with the battery current.

Rusting of Steel in Concrete.

The draft report of the science standing committee on the "Rusting of Steel Inside a Concrete Covering," which was presented at a recent meeting of the Concrete Institute, stated that a circular was issued in 1909 by the Concrete Institute asking for observations on the question whether rusting of steel takes place when covered by concrete, and was sent to 1000 engineers and others engaged in concrete construction.

Only 111 replies were received. Forty-seven contained results of definite observations, in which 26 cases of rusting had come under notice, and in 43 cases no rusting had been found.

As a result of these investigations the committee has arrived at the following conclusions: Reinforced concrete is as durable as plain concrete in any situation provided that certain precautions are taken in construction.

The cement, sand, stone, etc., must be of good quality, and must be carefully and thoroughly mixed and scientifically proportioned, so as to be practically waterproof and airproof. The mixture must be fairly wet and must be well punned into position to minimize voids. The aggregate should be as non-porous as possible, and no aggregate known to have a chemical action on steel should be used. The aggregate should all pass through a $\frac{3}{4}$ -in. mesh. The concrete covering should never be less than $\frac{1}{2}$ in., and with round or square bars the covering should not be less than the diameter of the bar. In structures exposed to the action of water or damp air the thickness of covering should be increased at least 50 per cent, or the size of the aggregate should be reduced so as to ensure a dense skin. Structures exposed to very severe conditions should have the concrete covered with some impervious coating.

The reinforcement should allow sufficient space between one piece and its neighbor for the concrete to pass and to completely surround every part of the steel. All steel should be firmly supported during the ramming of the concrete to avoid displacement. It should not be oiled or painted, and thick rust should be scraped and brushed off before placing in position.

The scantling of the various members of the structure should be sufficient to prevent excessive deflection. If electric mains are laid down care must be taken that no current is allowed to pass through the reinforced concrete. Fresh water should be used in mixing, and aggregates charged with salt should be well washed.

Engineering Imports and Exports.

The Board of Trade returns for January and February show that the imports of iron and steel, including manufactures, amounted to £1,689,512, or £328,048 more than during the

corresponding period of last year; and the exports were £7,196,410, showing an increase of £609,054. The imports of other metals and manufactures thereof were £4,318,634, and the exports £1,708,186, a decrease of £83,083 in imports and an increase of £96,000 in exports. The imports of electrical goods last month were £231,549, an increase of £9,567, and exports reached £428,724, giving an increase of £75,880. The imports of machinery are valued at £884,912, an increase of £235,957, and the exports at £4,714,446, an increase of £693,878. Imports of new ships were £37,092, an increase of £36,690; exports amounted to £620,847, a decrease of £1,665,134.

Market Prices.

March, 1911.

Copper has not varied much this month. Opening at £54.13.9 it reached £55.1.3 by the 15th, afterward easing off to £54.17.6, and is now (29th) at £54.15.0.

Tin has been over a 10-pound range, but rather less jerkily than before. Starting at £189.10.0 it had dropped by the 15th to £178.10.0, afterward recovering to £182 and now quoted £185.17.6.

Lead has been depressed, dropping from £13.12.6 to £13.10.0 by the 15th and ultimately to £13.5.0.

Hematite has also fallen. Opening at 66/2 it was 65/- at midmonth and now shows 64/3.

Pig Iron (Scotch) has dropped similarly from 54/9 to 54/4½ and then to 53/7½.

Cleveland Warrants opened at 48/8½ and dropped steadily to 48/3 (15th) thence to 47/7½.

India rubber has been cheaper, falling from 7/1, the opening price, to 6/10 by the 8th and 6/6½ by the 15th; was 6/7½ on the 22d and 5/11½ on the 29th, closing at 5/9½.

Alum, lump, loose, per ton.....	£5.12. 6.
Antimony, black sulphide powder.....	22. 0. 0.
Borax, British refined crystal.....	16. 0. 0.
Sulphate of ammonia, f. o. b. Liverpool, per ton.....	14. 7. 6.
Sal-ammoniac, lump, firsts, delivered U. K., per ton.....	42. 0. 0.
Copper sulphate, per ton.....	19.17. 6.
Camphor, 1-oz. tablets.....	0. 1.10.
Caustic soda, ash, 48 per cent ordinary, per ton.....	5.10. 0.
Shellac, standard T. N. Orange spots, per cwt.....	3.13. 0.
Sulphur, recovered, per ton.....	5. 0. 0.
Carbolic acid, liquid, 97/99 per cent, per gal.....	0. 1. 5.
Hydrochloric acid, per cwt.....	0. 5. 0.
Creosote, ordinary good liquid, per gal.....	0. 0. 2.
Naphtha, solvent, 90 per cent at 160° C., per gal.....	0. 0. 9.
Petroleum, Russian, spot, per gal.....	0. 0. 5.
Copper ore, 10 to 25 per cent unit.....	9/1½ to 9. 7.
Tin ore, 70 per cent, per ton.....	£112 to 114.0. 0.
Mica, small slab, in original cases, per lb.....	.6d. to 1. 0.
Litharge, flake, per ton.....	15.10. 0.
Quicksilver, per bottle, Spanish, 75 lb.....	£9.7.6 to 12. 0. 0.
Zinc sheets, V. M., f. o. b. Antwerp.....	27.10. 0.
Red lead, genuine, per ton.....	16. 0. 0.
Bleaching powder, 35 per cent, per ton.....	4. 5. 0.
Platinum, per ounce, nominal.....	8. 6. 6.

On the month the following differences are noted:

Lower.	Amount.
Hematite	£0. 2. 0.
Pig Iron (Scotch).....	0. 1. 7.
Cleveland Warrants	0. 1. 3½.
Tin ore	11. 0. 0.
India rubber, para.....	0. 1. 3½.
Tin	3.12. 6.
Lead	0. 7. 6.
Higher.	
Sulphate of ammonia.....	0. 5. 0.
Shellac, T. N. Orange spot.....	0. 1. 0.
Carbolic acid	0. 0. 1.
Copper, per ton.....	0. 1. 3.

The Congress of Technology in Boston.

The Congress of Technology which met in Boston on April 10 and 11 in celebration of the semi-centennial of the signing of the charter of the Massachusetts Institute of Technology was a pronounced success.

The opening session of the Congress was begun with an address by President Maclaurin of the Institute, who spoke on "Some Factors in the Institute's Success," and attributed that success primarily to the method of instruction, now everywhere accepted, but not long ago a debated venture.

"Apart from his appreciation of the value of all sound learning," said Dr. Maclaurin, "Wm. Barton Rogers, the founder and first president of the Institute, saw clearly that the whole controversy as to the relative merits of science and the classics in the field of education missed the mark by placing the emphasis in the wrong place. He understood that when one gets to the root of things in education, the *method* rather than the *subject* is of supreme importance, and his insistence on the value of method in teaching was the cardinal doctrine in his creed and the one that has contributed most to the success of the Institute. His fundamental idea here was not original with Rogers. It has been clearly expressed before, but rarely, if ever, adopted definitely as the basis of educational method and applied systematically throughout. The idea is familiar to us all to-day, the idea of *learning by doing*."

The daylight hours of the second day were given over to the presentation of papers on various aspects of applied science. These papers were grouped in six divisions, and the times of reading were so arranged that the general public, a large number of whom had received personal invitations, were enabled to hear papers in several divisions on topics in which they were particularly interested.

The result of these sessions amply justified the plan. Every session was very largely attended, and as the papers dealt not with educational or technical abstractions but were on the contrary striking and vital reports from the actual field of industrial work, the large audiences gained a better conception than would otherwise have been possible of the fashion in which applied science has remade the life and habits of the world within the last half century. Some of these papers are printed elsewhere in this issue.

The other main object of the Congress was achieved with equal certainty. The papers were all given by Technology Alumni and members of the faculty and the great range of accomplishment which the papers reported were a splendid certificate of merit and efficiency running to the credit of the men trained at the Institute.

Another feature that is perhaps of more importance than either of the two already mentioned is that the Congress has set clearly before the public the needs and the possibilities of what the speakers on Tuesday evening called the "New Technology." The high standard of the Massachusetts Institute of Technology, and its well deserved fame as one of the very foremost technical schools in the world, hardly need reiteration. But the very success of the Institute has brought it to a point where insufficient endowment and cramped quarters threaten seriously to interfere with its future usefulness unless the obstacles are very soon removed.

The banquet in Symphony Hall on Tuesday evening, April 11, provided a significant sign of deep appreciation of this need both by the alumni of the Institute and by many others outside of its immediate ranks. The enthusiasm of the thousand alumni and guests who filled the floor of the hall was reflected in the words of the speakers, who included two such notable figures in Institute affairs as President Lowell of Harvard, long a member of the Corporation of Technology, and President Emeritus Eliot of Harvard, who was professor of chemistry in the original Institute faculty.

The temper of this great meeting was significant in showing a sharp consciousness of a new era created by applied science;

of the important part that has already been taken by graduates of the Massachusetts Institute, and of the pressing need, especially from the point of view of the interest of Massachusetts, that the Institute should be immediately equipped with the additional means for enabling it to continue in the future as it has been in the past, a leader in technical education.

The practical earnestness of the alumni in doing their full share toward making possible the "New Technology" was shown in three announcements made by President Maclaurin from the platform after the banquet. One alumnus, who wished his name withheld, has offered to the Institute a tract of 1000 acres of land in Maine, well suited to the uses of a summer school in civil engineering. Other alumni have definitely pledged themselves to give a very large part of the price necessary for buying a new site for the Institute. Edward N. Hagar, Tech '93, president of the Universal Portland Cement Company, has promised as a gift all the cement needed for erecting the new buildings in reinforced concrete. Meanwhile, the question of the site itself, Dr. Maclaurin said, has been narrowed to a choice between three sites, all of which are within a short distance of the present buildings. It is expected that this question of a new site, upon which everything else in the development of the Institute depends, will very soon be settled.

The Western Metallurgical Field

Dredging in South Dakota.

A Denver corporation known as the Castle Creek Hydraulic Gold Mining Company is preparing to carry on dredging operations on Castle Creek, near Mystic, S. D., this summer. About 700 acres of ground were acquired by the company, most of which is amenable to dredging, and over 100 acres of which have been proved by bore holes. The average value of this ground was proved to be \$1.30 per yard, most of the gold being coarse and easily recovered. It is estimated that the cost of dredging will be very low, possibly as low as 5 cents per yard, as the ground contains no large boulders and there are no unusual obstacles to be overcome.

The dredge, which is now being built, will be in operation this summer. It is of the type which has proved so successful in California, with 5-cu. ft. buckets, and a hull measuring about 100 ft. x 36 ft. at water line. It will be operated by electricity generated at the company's power plant, which comprises four 100-hp boilers, a 300-hp Corliss engine and generator. The power requirement under full load is estimated to be 240 hp.

Winter operation is to be made possible by a suitable steam heating plant, with an inclosure over the stacker. The depth to bedrock is about 35 ft., which gives a large yardage on the area already proved. If the first year's operations prove successful it is possible that another dredge will be built to work on the other end of the tract. Assays on the fineness of the gold have given results of 947.5 fine.

Copper Concentration.

The work of the Utah Copper Company in concentrating large quantities of low-grade copper ore is generally conceded to be in the front rank of concentration. The report comes from Butte that representatives of the Anaconda Copper Company have been investigating the methods of the Utah company, with a view to making some changes in the Montana mills. The devices particularly attracting attention are the Garfield roughing table and the Janney classifier, the latter being an invention of the mill superintendent of the Utah Copper Company.

The roughing table has proved its value in preparing a lean pulp for treatment on standard tables by getting rid of a large quantity of gangue, thus practically making an enriched ore for the regular tables. The Janney classifier has been an improvement in the treatment of fine pulps, and is used in both the Utah mills.

At Anaconda jigging is the main treatment and is carried to

a fine point, the smallest jig concentrate being 1 mm in size. Following this are the Wilfley tables, but a large quantity of slime escapes treatment and is impounded. There are no vanners in the Anaconda plant, while in the Utah plants the vanner is relied on for a large percentage of the recovery. It is said that experiments will be made at Anaconda to test the value of the roughing table between the jigs and Wilfley tables, and that Janney classifiers and vanners will be tried on the finer sizes not treated on the Wilfley tables.

The Nevada Consolidated also is reported to contemplate experiments with various slime tables for the purpose of reducing the present slime losses, which are high on this ore. In the smelting department of the same company alterations are being made to test the basic lined converter. Should this method of converting prove successful, and it probably will be as successful there as at Utah, the old battery of acid-lined converters will be displaced by those of the new type.

Macquisten Tubes in Idaho.

Of the various flotation processes which have been proposed or operated, the Macquisten tube is one of the most interesting. The more common flotation processes make use of oil or acid, or both, to make the mineral particle buoyant, but the Macquisten process makes use of a different principle, viz., the varying action of mineral and gangue particles to the surface tension of water. Sulphide minerals are apparently unable to overcome the surface tension of water when delivered onto its surface, and, therefore, float, while gangue particles promptly sink. Thus for sulphide mineral particles, gravity is a lesser force than the surface tension of water.

The Macquisten tube is a cast-iron tube about 6 ft. long and 1 ft. in diameter. On its inner surface it has a helical groove and on its outer surface two tires which rest on supports. It is revolved in a horizontal position, and the ground pulp is delivered at one end. Being revolved in the direction of the helical groove in the interior, the pulp is screwed through the tube to the discharge end. Naturally in the revolutions of the tube the pulp in any groove is raised out of the water, which is maintained at a definite height in the tube, and on sliding down the side of the tube the mineral particles tend to float while the gangue sinks and is carried to the next groove. This separation depends somewhat on the angle of emergence of the pulp from the water, as the greatest floating effect is obtained when the mineral is directed onto the surface of the water at a small angle.

The latest important installation of this process is in the Morning mill of the Federal Mining & Smelting Company, Wallace, Idaho. Its object will be the treatment of low-grade zinc middlings. The first unit will be of 50 tons capacity and will use about 120 tubes. If this proves successful, additional tubes will be added to give a capacity of 250 tons per day. The plant should be in operation in May or June.

Cyanide Tailings Treatment.

Another interesting plant which will be in operation about the same time as the one just mentioned is that of the United States Reduction & Refining Company, at Florence, Col. At this place are the large tailings dumps of the old Union plant and the Metallic Extraction Company. There are upward of 300,000 tons of material in each dump, representing the tailings from the early application of the cyanide process on Cripple Creek ores.

The success which the company has met with in cyaniding old tailings at the Standard plant at Colorado City has led to the erection of the present plant at Florence. About 400 tons of tailings will be treated daily at the new plant, and a good net profit is anticipated.

There has been some talk about starting the smelter owned by this company at Canon City. This plant formerly treated zinc ores and produced pigment, but it has not been operated for several years. Several proposals have been made by prospective

leasers to again operate it on zinc ores, but no definite results have transpired. Experiments also have been made by outsiders on the old dump of the smelter to see whether a profitable extraction of zinc could be made from it, but for some reason or other no further action was taken.

Tungsten from Nevada.

The first shipment of tungsten concentrates from White Pine County, Nevada, was made in March by the United States Tungsten Corporation. The mill is operated by water-power when water is plentiful and by an auxiliary steam plant at other seasons. The latter plant is inadequate for the needs of the mill, and consequently operations have been on a small scale during the winter. It is expected that this summer's work will result in a steadier output.

The grade of the concentrate is up to the standard of 60 per cent tungstic acid.

Mason Valley Smelter.

The construction of this plant in the Mason district, Nevada, is progressing rapidly and satisfactorily. Some time ago the contracts were let for the electric equipment, and more recently the bid of the American Bridge Company for the structural steel work was accepted. The contract calls for 400 tons of structural steel at a cost of about \$40,000. This provides for the construction of blast furnace and converter building, sampling mill, power house and ore bins. The initial capacity of this custom copper smelter will be 800 tons per day, but this can be increased easily to 2000 tons on demand.

American Mining Congress.

The fourteenth annual session of the American Mining Congress will be held in Chicago, Oct. 23-28, 1911. This probably will be the last session of the congress at which the present delegate system will prevail. At present delegates to the congress may be appointed by the president, governors, scientific societies, etc., but in the future it is planned to have a congress of members only, and to have this congress represent the different sections of the United States. The reorganization scheme also includes the establishment of State chapters to carry on the particular work of the State and to send delegates to the annual congress. In this way the congress will not be so unwieldy and cumbersome as it is now, and better work can be done than before.

The Non-Ferrous Metal Market.

The non-ferrous metals were without feature on the market during April. Copper has tended to decline, as has spelter, but lead has showed a slight spring improvement. Purchases seem to be only for immediate needs.

Copper.—The market has been marked by dullness, and large business has been consummated only at some concession in price. Lake copper is quoted lower than in our last report, being $12\frac{1}{4}$ to $12\frac{3}{8}$ cents. Electrolytic is quoted at 11.95 to 12.05 cents.

Lead.—The April market showed an advance over March, and this improvement seems to hold. St. Louis lead is quoted at 4.25 to 4.27½ cents, and New York, 4.40 to 4.42½ cents. The demand for Missouri lead has shown improvement during the month.

Spelter.—Although reports are to the effect that consumers are not well supplied, the business in spelter is quiet. Prices have shown a tendency to decline from day to day, and the market is generally lower than in March. St. Louis spelter is quoted at 5.22 to 5.27, and New York, 5.37 to 5.42.

Tin.—Transactions abroad indicate that the foreign syndicate dominates that market, but developments in the domestic market during the month showed that the influence of the London market was not strong here. April tin showed a steady increase in price as compared with March, and was quoted at 42½ cents, New York.

The Iron and Steel Market.

The event of the month, as regards iron market movements, was the settlement of Lake Superior iron ore prices for the season, at 50 cents below the 1910 schedule, making this season's prices as follows compared with prices in the past 10 years:

	—Old Range—		—Mesabi—	
	Bessemer	Non-Bessemer	Bessemer	Non-Bessemer
1901.....	4.25	2.85	2.75	2.35
1902.....	4.25	3.00	3.00	2.60
1903.....	4.50	3.60	4.00	3.20
1904.....	3.00	2.60	2.75	2.35
1905.....	3.75	3.20	3.50	3.00
1906.....	4.25	3.70	4.00	3.50
1907.....	5.00	4.20	4.75	4.00
1908.....	4.50	3.70	4.25	3.50
1909.....	4.50	3.70	4.25	3.50
1910.....	5.00	4.20	4.75	4.00
1911.....	4.50	3.70	4.25	3.50

Since 1907 the base guarantees have been 55 per cent iron for Bessemer ores and 51.50 per cent iron for non-Bessemer ores, in the natural state, with the phosphorus basis for Bessemer ores .045 per cent, dried at 212°. Prior to 1907 the basis for several years was 56.70 per cent for Bessemer ores and 52.80 per cent for non-Bessemer. Prices are for ore on Lake Erie docks.

The settlement of season prices was unusually late, since the season has nominally commenced, although on account of the light demand there will be relatively little ore moved before July. Occasionally season prices have been fixed before the end of the preceding calendar year. This season found a complicated situation. The advance for the season of 1910 was determined upon late in December, 1909, when the pig iron market had shown dullness and a declining tendency for more than a month. At the moment the condition was regarded as only temporary and the market was expected shortly to resume the steady upward movement which had characterized it from May to the beginning of November. Instead it declined steadily almost throughout 1910, leaving ore prices quite out of line with prices of pig iron, and even of finished steel products. The very badness of the market, however, constituted one argument for maintaining ore prices, inasmuch as merchant furnaces were left in many instances with large stocks of pig iron or ore, or both, upon which a reduction in ore for the new season would necessarily write a depreciation. The steel interests, furthermore, were intent upon preserving the existing level of finished steel prices in face of a very light demand, and decried a reduction in ore on account of the sentimental influence. A meeting of ore interests was held in Cleveland, April 11 and another of ore interests with some of the steel producers in New York, April 18. On Friday morning, April 21, the Sherrill Furnace Company, commonly known as the Snyder interest, announced that it had sold two lots aggregating 200,000 tons of Mesabi Bessemer ores and four lots aggregating 550,000 tons of Mesabi non-Bessemer ores, at \$4.25 and \$3.50 respectively. This informal method of opening the selling season, supplanting the method of a few years ago of holding a meeting of ore interests and then announcing the result of the deliberations, is due to the desire of the ore interests to avoid the appearance of conflict with the later interpretation of the Sherman law of 1890. The ore interests are satisfied to have ore prices for the season on the basis thus indicated.

Total sales of merchant ore for the season are not likely to be heavy, and may even fall short of 5,000,000 tons. In the three years of heaviest movement, 1907, 1909 and 1910, the total ore shipped from the Lake Superior region was between 42,000,000 and 44,000,000 tons, nearly a fourth being merchant ore sold in the open market, the balance being made up of a relatively small tonnage moved on long term contracts, and moved by the producer-consumer class. Various estimates of the

prospective season movement for 1911 range from 25,000,000 to 35,000,000 tons.

April opened with pig iron production at the rate of about 26,000,000 tons a year, there having been practically no change during March, after the sharp increase in January and February. The current production was passing into steel mill, foundry and other consumption, but new orders for finished product were not being booked at a rate to support the production, and new buying decreased until the middle of the month, when the state of the iron and steel market as a whole was one of stagnation. Production began to be curtailed by the middle of the month, the United States Steel Corporation leading, as it firmly follows a policy of regulating its pig iron output to the shipments of finished steel products. Independent steel interests curtailed somewhat more slowly, and probably accumulated some pig iron during the month. The country's production rate at the close of the month was probably well under 25,000,000 tons, while shipments of finished steel products in the second half of the month were at a lower rate than this output would support. There has been little change in production by merchant furnaces, as the demand for merchant pig iron had not grown as brisk early in the year as the demand for finished steel products.

The position at the beginning of May is that buying of finished products is at a much smaller rate than early in the year, and falling quite short of justifying the rate of production, which is declining in consequence. An improvement in buying is to be expected this month, on account of the progress of the season, involving outdoor work and the depletion of stocks due to the extreme timidity of buyers late in March and during April, but it is questionable whether there will be sufficient increase to arrest the decline in production, which has been forced by the deficiency in buying already noted.

Prices of finished steel products are unchanged, and producers do not regard the reduction in ore as cause for any revision. As to both pig iron and finished steel products, the reduction in ore is held to have been discounted long ago by the declines in the more finished products.

Pig Iron.

The market has been extremely quiet, the month's turnover being the lightest for months. Prices have not changed appreciably. Early in the month the premiums demanded for second half delivery began to disappear, the south leading as usual, so that it became possible to buy southern iron for deliveries to the end of the year on the basis of \$11, Birmingham. At the same time it appeared probable that for prompt delivery the price could be shaded 25 cents, but this has not been very seriously tested. The reduction in ore prices brought out considerable enquiry for northern iron, but this enquiry seemed to arise purely from a desire to test the market and upon furnaces quoting former prices business did not result. The furnaces insist that the ore reduction was discounted months ago by declines in pig iron, but the matter will ultimately depend upon the competition. The lake front merchant furnaces have a margin above cost which they could if necessary shade, while the Mahoning and Shenango Valley furnaces, whose selling prices have been practically at cost, based on the reduced ore prices, have large stocks, and the competition may force them to accept losses. We quote at valley furnaces, 90 cents higher delivered Pittsburgh: Bessemer, \$15; basic, \$13.75; No. 2 foundry, \$14; malleable, \$13.75 to \$14.

Steel.

Shipments of billets and sheet bars on contracts have decreased somewhat. There has been no new business of importance, but on a few odd lots of open-hearth billets and sheet bars regular prices have been shaded. We continue to quote billets at \$23 and sheet bars at \$24, f.o.b. maker's mill, Pittsburgh or Youngstown, with rods nominally at \$29, Pittsburgh.

Finished Steel.

The United States Steel Corporation's unfilled orders de-

creased 3,252,274 tons during 1910, and increased 436,162 tons in January, 289,624 tons in February and 46,758 tons during March, standing at 3,447,301 tons on March 31. A decrease during April is expected to be shown by the report to be made public May 10.

Finished steel products are practically unchanged in price. There has been somewhat more shading in sheets, but the former basis is at least nominally in force. The advance of 5 cents per 100 lb. scheduled for April 1 in spikes became effective in Pittsburgh territory, but not in the West, so that the spike market stands at \$1.60, Pittsburgh, and \$1.65, Chicago, base, subject to extras according to the new list adopted February 1 last. Regular price f.o.b. Pittsburgh, except where otherwise stated, are as follows:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill, except Colorado.

Plates, 1.40 cents for tank quality.

Shapes, 1.40 cents for beams and channels, 3 in. to 15 in. inclusive, zees and angles, 2 x 3 and larger.

Steel bars, 1.40 cents, base; iron bars, 1.35 cents, Pittsburgh; 1.20 to 1.25 cents, Chicago.

Wire nails, \$1.80, base, per keg; plain wire, 1.60 cents, base; galvanized barb wire, 2.10 cents; painted barb wire, 1.80 cents.

Black sheets, 28 gage, 2.20 cents; galvanized, 3.20 cents; blue annealed, 10 gage, 1.65 cents; painted corrugated roofing, \$1.55 per square; galvanized, \$2.75.

Tin plates, 100-pound cokes, \$3.70 per box.

CORRESPONDENCE.

Separation of Oxygen by Cold.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—Mr. J. J. Smith's letter deals with two points: one theoretical, the other practical. Taking the theoretical first, I have nothing to add to your note at the end of his letter. Mr. Smith has evidently taken Clausius' equations for reversible processes and applied them to irreversible processes. The increase of entropy due to the mixture of two inert gases is not an invention or fallacy of my own; it is quite well known, and Mr. Smith will find it discussed in the works of his own eminent countryman, the late Professor Willard Gibbs.

As to the discrepancy between my figures and those of M. Marchis: the first proofs of my paper had a slip in arithmetic and a few copies were sent out before I corrected it. I merely mixed up watts and kilowatts, a small matter which sometimes gives unexpected results.

At any rate the result astonished and disappointed me until I realized its absurdity and looked for the error. The figure ought to be 120 kilowatts, not 120,000; the prices coming out at about 25 cents a ton. The error justified Mr. Smith in attacking the theory on the ground that the result proved its error.

As this error of mine may have got about I am especially glad of a chance of correcting it.

London, England.

JAMES SWINBURNE.

[The sixth and fifth paragraphs from the end of Mr. Swinburne's paper, that is, the last three lines in the first column and the first nine lines in the second column of page 36 of our January issue, should read as follows, according to the corrected copy of the paper which Mr. Swinburne has kindly sent us:

"Assuming the ideal energy needed to separate a kilogram of air into its gases to be 40,000, the question is: What would it cost in practice? On a large scale it may be safe to say 100,000 joules, or a ton would need 120 kw hours. Taking the cost of a kilowatt hour as low as 0.2 cent, this means 25 cents a ton.

"It certainly looks as if oxygen at this order of figure could be used for blast furnace work. Taking a blast furnace as using four and a half tons of air per ton of iron, to increase the oxygen content by 10 per cent of the oxygen content comes out at 2½ cents per ton of pig. This shows that the Linde process may be useful on a large scale."—EDITOR.]

Metallography and Its Industrial Importance.*

BY ALBERT SAUVEUR.

This paper deals with a subject which was not taught at the Massachusetts Institute of Technology during my stay at that institution, which was not even mentioned in the classroom. Indeed, metallography at that time had just been born and had not attracted greater attention than is generally bestowed on infants outside the family circle.

If I have contributed a mite to the growth of the child—to the progress of metallography—why, then, should my Alma Mater be entitled to any credit? Why should I not claim for myself and retain undivided whatever merit be attached to the contribution of my mite?

The reply is obvious. While I did not acquire even the rudiments of metallography in passing through the institute I entered it with an untrained mind and left it with a mind satisfactorily trained for scientific pursuit. This is my greatest debt of gratitude to my Alma Mater. It is why the institute is entitled to the lion's share of the aforesaid credit.

This incident is only a passing illustration of what, to me, is becoming more and more evident as the years go by, namely, that it is not the knowledge acquired at the school or university which is later of vital importance to us, but rather the training of the mind which the acquirement of that knowledge implies. It is this training—this peculiar attitude of the mind—which distinguishes an educated from an uneducated man.

Have not most of us forgotten a large portion of the knowledge obtained at college 10 years after graduation? Do we cease then to be educated men? Are we less educated? Clearly not, for we retain, and possibly have developed further, that mental attitude—that way of looking at things—which distinguishes the educated man.

If this be so does it matter then what we do study while at the university or technical school? While I am not prepared to say that this is immaterial provided we study enough to train our mind, I do not believe that the selection of courses has the importance generally attached to it. I do believe that the educational value of a subject depends more upon its mind training power than upon the specific kind of knowledge which it aims to impart.

Hence the value of mathematics, even for those who never expect to be called upon to perform, after leaving college, more than the four elementary operations. It is, of course, evident that the natural bent of the mind should be followed in the selection of studies—that persons with decided scientific inclination should take up chiefly scientific studies, those with literary taste, classical subjects, etc.—but the value of greater specializing for the purpose of education is, to me, becoming daily more doubtful.

A scientific education should be obtained in four years, during which a sound knowledge of the pure sciences and the rudiments of the most important applied sciences should be acquired, thereby securing the desired mental attitude and scientific way of thinking. If the student then desires to take up as his life's work the application of science in some well-recognized field, such as one of the various engineering professions, his general scientific training should be followed by a course of two years of as practical a character as possible and devoted exclusively to applied science in his chosen field.

During these two years specializing could hardly be carried too far. The student, for instance, should make up his mind not only to specialize in mining and metallurgy, but in mining *or* metallurgy, and in the latter case whether his special training will be in the metallurgy of iron and steel or of the non-ferrous metals. Should he select iron and steel, his two years of post-graduate work should be devoted exclusively to that one subject, or practically so.

In short, for the purpose of education and general fitness to take up a man's burden, let us provide a program of study as broad as possible, avoiding specialization, while for preparation in any one field of applied science let us frankly face the need of specializing; at this stage it could hardly be too excessive.

The prevailing practice is, of course, very different, the young man being made to specialize upon entering college, or possibly upon beginning his second year, and, therefore, at a period when very few can make an intelligent choice. Should he then decide to qualify himself for useful work in the manufacture of iron and steel he is required to follow for three or four years a number of prescribed studies of mining methods, ore dressing, the metallurgy of the non-ferrous metals, while learning relatively very little of his chosen subject: iron and steel. His general scientific training is narrowed while the specialized knowledge acquired is not the kind he wanted.

He leaves college a less broad man than what he might have been with specific information in his chosen field too limited for immediate useful application. Nor can it be reasonably argued that six years is too long a period of time to devote to preparation for engineering work, for it would be an admission that professional work in applied science does not call for as broad and careful training as that now required by the best schools for the practice of law or of medicine.

Twenty years ago the science of metallography was practically unknown and it is only within the last fifteen years that it has been seriously considered by metal manufacturers and consumers as a valuable method of testing and investigation. That so much has been accomplished in so short a time is highly gratifying to the many workers, practical or scientific, who have contributed by their efforts to the progress of metallography.

To realize the practical importance of metallography it should be borne in mind that the physical properties of metals and alloys—that is, those properties to which these substances owe their exceptional industrial importance—are much more closely related to their proximate composition than to their ultimate composition, and that microscopical examination reveals, in part at least, the proximate composition of metals and alloys, whereas chemical analysis seldom does more than reveal their ultimate composition.

It will bear repeating that from the knowledge of the proximate composition of a certain industrial metal or alloy we are able to infer its properties and, therefore, predict its adaptability with a much greater degree of accuracy than if we knew only its ultimate composition.

The analytical chemist may tell us, for instance, that a steel which he has analyzed contains 0.50 per cent of carbon, without our being able to form any idea as to its properties, for such steel may have a tenacity of some 75,000 lb. per square inch or of some 200,000 lb., a ductility represented by an elongation of some 25 per cent, or practically no ductility at all; it may be so hard that it can not be filed or so soft as to be easily machined, etc.

The metal microscopist, on the contrary, on examining the same steel will report its structural, i.e., its proximate, composition, informing us that it contains approximately 50 per cent of ferrite and 50 per cent of pearlite, and we know at once that the steel is fairly soft, ductile and tenacious, or he may report the presence of 100 per cent of martensite and we know that the steel is extremely hard, very tenacious, and deprived of ductility.

Which of the two reports is of more immediate practical value, the chemist's or the metallographist's? Surely, that of the metallographist.

Nor is it only in the domain of metals that we find such close relationship between properties and proximate composition, for, on the contrary, it is quite true of all substances. How many organic bodies, for instance, have practically the same ultimate composition and still are totally unlike in properties because of their different proximate composition, i.e., different grouping

*A paper presented at the Congress of Technology at the 50th anniversary of the granting of the charter of the Massachusetts Institute of Technology.

and association of the ultimate constituents. If we were better acquainted with the proximate composition of substances many unexplained facts would become clear to us.

Unfortunately the chemist too often is able to give us positive information in regard to the proportion of the ultimate constituents only, his reference to proximate analysis being of the nature of speculation. Ultimate analysis has reached a high degree of perfection in regard to accuracy as well as to speed of methods and analytical chemists have built up a marvelous structure calling for the greatest admiration. Their searching methods never fail to lay bare the ultimate composition of substances. But how much darkness still surrounds the proximate composition of bodies and how great the reward awaiting the lifting of the veil!

The forceful and prophetic writing in 1890 of Prof. Henry M. Howe, M. I. T., '71, naturally comes to mind. Speaking of the properties and constitution of steel, Professor Howe wrote:

"If these views be correct, then, no matter how accurate and extended our knowledge of ultimate composition, and how vast the statistics on which our inferences are based, if we attempt to predict mechanical properties from them accurately we become metallurgical Wigginses. * * *

"Ultimate analysis never will, proximate analysis may, but by methods which are not yet even guessed at, and in the face of fearful obstacles.

"How often do we look for the coming of the master mind which can decipher our undecipherable results and solve our insoluble equations, while if we will but rub our own dull eyes and glance from the petty details of our phenomena to their great outlines their meaning stands forth unmistakably; they tell us that we have followed false clues and paths which lead but to terminal morasses. In vain we flounder in the sloughs and quagmires at the foot of the rugged mountain of knowledge seeking a royal road to its summit. If we are to climb, it must be by the precipitous paths of proximate analysis, and the sooner we are armed and shod for the ascent, the sooner we devise weapons for this arduous task, the better.

"By what methods ultimate composition is to be determined is for the chemist rather than the metallurgist to discover. But, if we may take a leaf from lithology, if we can sufficiently comminute our metal (ay, there's the rub!) by observing differences in specific gravity (as in ore dressing) in rate of solubility under rigidly fixed conditions, in degree of attraction by the magnet, in cleavage, luster, and crystalline form under the microscope, in readiness of oxidation by mixtures of gases in rigidly fixed proportions, we may learn much.

"Will the game be worth the candle? Given the proximate composition, will not the mechanical properties of the metal be so greatly influenced by slight and undeterminable changes in the crystalline form, size and arrangement of the component minerals, so dependent on trifling variations in manufacture as to be still only roughly deducible?"

The above was written before the days of metallography, or at least when metallography had barely appeared in the metallurgical sky and when no one yet had fancied what would be the brilliant career of the newcomer. Metallography has done much to supply the need so vividly and timely depicted by Professor Howe, precisely because by lifting a corner of the veil hiding from our view the proximate composition of metals and alloys it has thrown a flood of light upon the real constitution of these important products. Has the game been worth the candle? Will any one hesitate to answer in the affirmative Professor Howe's question?

Professor Howe with his usual acumen was conscious of the fact that proximate analysis, while likely to reveal a great deal more of the constitution of metals than ultimate analysis ever could, might still leave us in such ignorance of their physical structure as to throw but little additional light upon the subject. His fear was certainly well founded and surely if the proximate composition had been obtained by chemical analysis it would indeed have told us little of the structure or anatomy

of the metals. In the domain of proximate composition chemistry can not do more for the metallurgist than it does for the physician.

Invaluable information chemistry does give without which both the physician and the metallurgist would be in utter darkness, but it throws little or no light upon the anatomy of living or inanimate matter. Its very methods which call for the destruction of the physical structure of matter show how incapable it is to render assistance in this, our great need.

The parallel drawn here between metals and living matter is not fantastic. It has been aptly made by Osmond, who said rightly that modern science was treating the industrial metal like a living organism and that we were led to study its anatomy, i.e., its physical and chemical constitution; its biology, i.e., the influence exerted upon its constitution by the various treatments, thermal and mechanical, to which the metal is lawfully subjected; and its pathology, i.e., the action of impurities and defective treatments upon its normal constitution.

Fortunately metallography does more than reveal the proximate composition of metals. It is a true dissecting method which lays bare their anatomy—that is, the physical grouping of the proximate constituents, their distribution, relative dimensions, etc., all of which necessarily affect the properties. For two pieces of steel, for instance, might have exactly the same proximate composition—that is, might contain, let us say, the same proportion of pearlite and ferrite and still differ quite a little as to strength, ductility, etc., and that because of a different structural arrangement of the two proximate constituents; in other words, because of unlike anatomy.

It is not to be supposed that the path trodden during the last score of years was at all time smooth and free from obstacles. Indeed, the truth of the proverb that there is no royal road to knowledge was constantly and forcibly impressed on the mind of those engaged in the arduous task of lifting metallography to a higher level.

Its short history resembles the history of the development of all sciences. At the outset a mist so thick surrounds the goal that only the most courageous and better equipped attempt to pierce it and per chance they may be rewarded by a gleam of light. This gives courage to others and the new recruits add strength to the besieging party. Then follows the well-known attacking methods of scientific tactics and strategy, and after many defeats and now and then a victorious battle the goal is in sight, but only in sight and never to be actually reached, for in our way stands the great universal mystery of nature: what is matter? What is life?

Nevertheless there is reward enough for the scientist in the feeling that he has approached the goal, that he has secured a better point of vantage from which to contemplate it. The game was worth the candle. And if scientific workers must necessarily fail in their efforts to arrive at the true definition of matter, whatever be the field of their labor, they at least learn a great deal concerning the *ways of matter*, and it is with the ways of matter that the material world is chiefly concerned. Hence the usefulness of scientific investigation, hence the usefulness of metallography.

Like any other science with any claim to commercial recognition, metallography has had first to withstand the attack and later to overcome the ill-will and reluctance of the so-called "practical man" with a decided contempt for anything scientific. He represents the industrial philistine clumsily standing in the way of scientific application to industrial operations. Fortunately, while his interference may retard progress, it can not prevent it. Had he had his own way neither the testing machine, nor the chemical laboratory, nor the metallographical laboratory, nor the pyrometer would ever have been introduced in iron and steel works.

In metallography, as in other fields of research, American workers, with very few exceptions, have been quite willing to let Europeans perform the arduous and generally unrewarded task of the pioneer, being content to wait before entering the

field until practical results were fairly in sight. Such course, which is never to be commended, becomes intolerable when accompanied, as it so frequently is, by the boasting attitude of the man believing himself smarter than his neighbor, whom he regards in the light of the cat drawing the chestnuts from the fire.

America, barring brilliant exceptions like Richards at Harvard and Noyes at Tech, does not as yet do her share of the pioneer's work in investigations which do not give evident indications of quick commercial returns. The unselfish, nay, self-sacrificing, spirit of the true scientist is of far rarer occurrence in the United States than it is in Europe, and especially in France. America has not yet produced a Pasteur nor a Berthelot, intellectual giants, profound scientific thinkers, whose conception of the duty of the scientist as a man is so lofty that they have despised the wealth within their easy reach to devote themselves unreservedly to the betterment of their country, or rather of the world, for they are morally so great that the entire world becomes their fatherland. Humanity claims them.

Speaking in 1904 of the practical value of metallography in iron and steel making, I wrote the following which it may not be out of place to reproduce here: "History, however, must repeat itself, and the evolution of the metallographist bids fair to be an exact duplicate of the evolution of the iron chemist; the same landmarks indicate his course; distrust, reluctant acceptance, unreasonable and foolish expectation from his work, disappointment because these expectations were not fulfilled and finally the finding of his proper sphere and recognition of his worth. The metallographist has passed through the first three stages of this evolution, is emerging from the fourth and entering into the last. For so young a candidate to recognition in iron and steel making this record is on the whole very creditable."

We may say to-day that he has definitely entered the last stage and that the adverse criticisms still heard from time to time, generally from the pen or mouth of ignorant persons, are like the desultory firing of a defeated and retreating enemy.

In the United States alone the microscope is in daily use for the examination of metals and alloys in more than 200 laboratories of large industrial firms, while metallography is taught in practically every scientific or technical school.

Harvard University.

The Florence-Goldfield mill was operated 365 days during 1910 and treated an average of 143.3 tons of ore per day. The total recovery of gold was 92.11 per cent; 58 per cent of this was shipped to the United States mint as bullion. The average cost of milling for the year was \$2.985 per ton. The distribution of the total cost of milling for the year follows:

Amalgamating	\$6,140.39
Assaying	1,740.60
Concentrating	12,490.45
Concentrating repairs	2,734.79
Crushing	16,704.57
Crushing repairs	9,716.57
Cyaniding	44,067.83
Cyaniding repairs	8,013.01
General superintendence and office....	2,922.61
Mill superintendence	3,669.66
Power and lighting	37,038.38
Tailings	1,390.19
Watching	1,387.21
Water	6,934.24
Water repairs	377.02

Total\$155,327.52

In percentages of the total cost, the different items of cost are as follows: Cyaniding and cyaniding repairs 33.5 per cent, power and lighting 23.8 per cent, crushing and crushing repairs, 17 per cent, concentrating and concentrating repairs, 9.8 per cent, etc.

Modern Ore Dressing Practice in Gilpin County, Colorado.

By H. C. PARMELEE.

A new standard has been set for concentrating mills in Gilpin County, Colorado, which is noteworthy because styles have not changed much there in the past forty years. The old milling methods, which were the result of varying conditions as to quantity and quality of ore, were just as simple and efficient as could be devised by the pioneers. Hence the development of the venerable slow-drop, high-discharge stamp mill, with inside



FIG. 1.—NEW 250-TON CONCENTRATING MILL OF THE FRONTENAC CONS. MINES, LTD., BLACK HAWK, COLO. OLD IRON CITY MILL IN RIGHT FOREGROUND.

amalgamation, for the treatment of surface quartz-gold ores and the Gilpin County bumper for the concentration of sulphides.

These devices probably were efficient in their day and for the class of ore they were designed to treat, but they do not adequately meet the demands of present practice. The inevitable change in other conditions has not been accompanied by a general disposition to abandon old styles of treatment and adopt new, even though the latter are of proved advantage. The tendency has been to hold to old methods, without always using the discrimination that marked their early use; the frank expression of some of the millmen being that "they are good enough." Under such conditions those who are progressive enough to depart from the old lines, even in the face of sceptical criticism, are entitled to credit and it is to be hoped that their example will be more widely followed.

The Frontenac Mill.

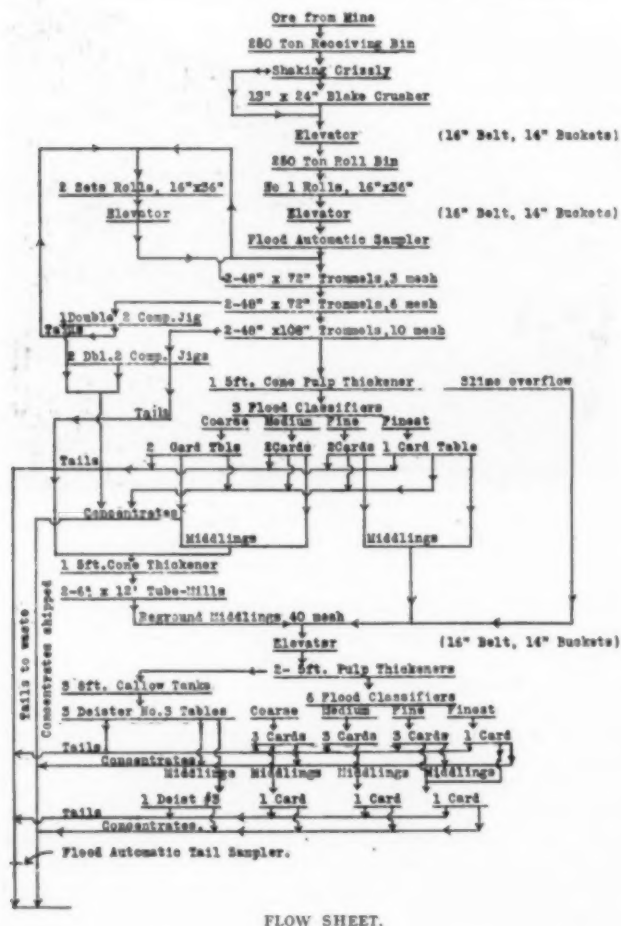
The Frontenac Consolidated Mines, Limited, an English corporation operating in Gilpin County, is represented locally by Mr. Henry P. Lowe, managing director. At his instigation the present Frontenac mill was built after two years' experimenting on methods of ore dressing to determine the best procedure and the most efficient machines. The mill, which is shown in Fig. 1, was designed by Mr. S. B. Tyler, general superintendent of the Frontenac company, and built by Peter McFarlane & Sons Iron Works Company, Denver. The view of the Frontenac mill also shows the adjoining Iron City mill in the right foreground. It was in the Iron City that Mr. Tyler conducted the preliminary experiments on Frontenac ore, testing several types of the various machines for long periods of time. The result is believed to be a rational system of treatment showing a marked advance in efficiency over former methods.

Frontenac ore is a mixed sulphide of iron, lead and copper, carrying gold and silver and occurring in a quartz and granite gangue. The minerals are mainly pyrite, with some galena and

tetrahedrite. The gold occurs mainly in the pyrite and the silver in the tetrahedrite. The pyrite and galena occur massive and are liberated from the gangue in condition for coarse concentration, but the tetrahedrite exists in thin seams and is not released save by fine grinding. This condition makes the recovery of the copper a difficult matter, as it is not until the ore is slimed that the highest saving can be made. The total value of the ore ranges from \$8 to \$10 per ton. The gold assays from 0.30 oz. to 0.35 oz. per ton; silver from 4 oz. to 6 oz.

Crushing, Screening and Jigging.

In general the system of treatment consists of crushing in stages, with intermediate concentration, beginning with the



FLOW SHEET.

coarsest size at which mineral is liberated from the gangue, and ending with slime. Specifically concentration begins in coarse jigs on $-3+6$ -mesh material and is continued in fine jigs, $-6+10$ -mesh, and from there on three sets of tables with one intermediate regrinding.

The accompanying diagrammatic flow sheet shows the steps in the treatment. Ore is delivered at the head of the mill by the district tramway and dumped into a 250-ton receiving bin, from which it flows through ordinary rack-and-pinion gates to the coarse crusher. This machine is of the Blake type, and the largest in the district, having a jaw opening 13 in. x 24 in., and a capacity of 750 tons in 24 hours. All coarse crushing, therefore, is done on one eight-hour shift, which is ample to provide the tonnage for 24 hours.

The crushed ore, reduced to a maximum size of 2 in., is elevated to a bin of like capacity to the crude-ore bin. From here it flows to a hopper fitted with a plunger feeder which discharges to the roughing rolls. These are 16 in. x 36 in. in size, making 60 r.p.m., and set $\frac{1}{4}$ in. apart. Their product passes to an elevator which feeds the trommel screen line.

The trommel line is in duplicate, three trommels in each train;

the first two are 4 ft. x 6 ft., and the third 4 ft. x 9 ft. Diagonal slotted punched screens are used, the first having 9 mm opening, the second 3 mm and the third $1\frac{1}{2}$ mm, corresponding to 3, 6 and 10-mesh respectively. The oversize from the first trommel is returned to the regrinding rolls, of which there are two sets, 16 in. x 36 in., making 80 r.p.m., and set close together. The reground pulp is returned to the screen line.

The undersize of the first trommel passes to the second, and that of the second to the third. The oversize of the second and third trommels comprises the feed for the coarse and fine jigs respectively. The final undersize of the trommel line is classified for table treatment.

Three double two-compartment Traylor jigs receive the screen products as stated above. All jigs make hutch concentrates—a pyrite-galena mixture. The coarse jigs treat $-3+6$ -mesh material. They are run at 220 r.p.m. with a $\frac{1}{4}$ -in. stroke. They are fitted with 4-mesh screen of No. 15 wire. The fine jigs treat the $-6+10$ -mesh pulp, have a speed of 280 r.p.m. and a stroke of $\frac{3}{8}$ in. Their screens are 6-mesh of No. 13 wire. Coarse jig tailings are reground in rolls with the first trommel oversize and returned to the screen line, while fine jig tailings are reground in tube mills and treated in the slime department.

The jig concentrates are dewatered and delivered to a bin by

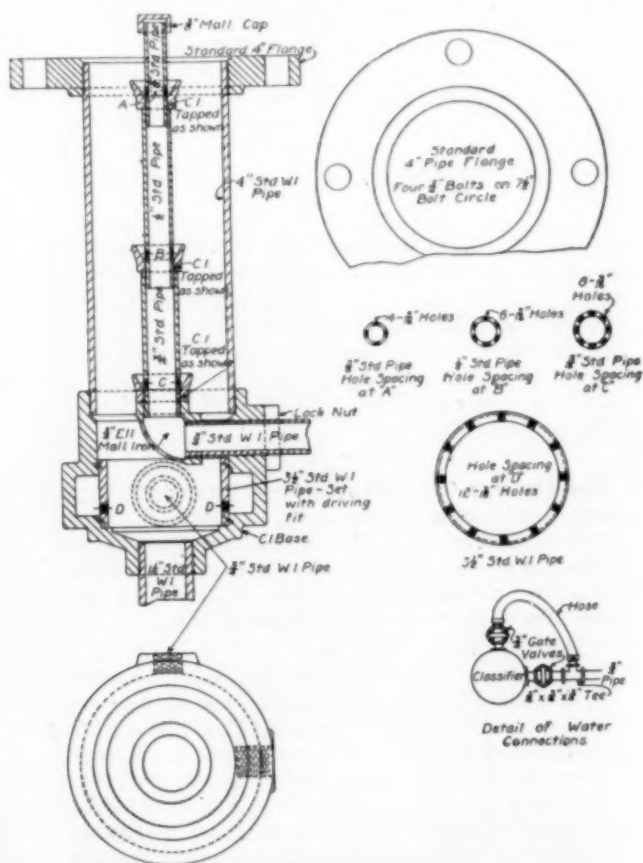


FIG. 2.—DIAGRAM OF FLOOD CLASSIFIER.

means of a shaking launder having a perforated screen bottom for a portion of its length. The launder is suspended from above by 1-in. boards, and has a fall of about 1 in. to the foot. A knocker movement at the upper end throws the concentrates toward the discharge, dewatering them as they pass over the screen bottom. This is a device of Mr. J. J. Fitzgerald, mill foreman, who first installed it some years ago at the Humphreys mill, Creede, Col.

Classification and Table Treatment.

The undersize of the 10-mesh trommel is classified for table treatment by Flood classifiers. This device, which is illus-

trated in Fig. 2, is a hydraulic tubular classifier, several of which may be arranged in a launder to receive successively that part of the pulp not taken out by the one immediately preceding. It consists of a vertical tubular sorting column, with a centrally located water pipe entering from below, capped at the top and perforated with three annular series of holes for the escape of the hydraulic water.

As the pulp flows into the sorting column it encounters the upward current of water from the annular jets, and each particle of pulp sinking to the bottom of the tube must pass each series of jets before it can escape through the discharge spigot. That portion of the pulp which is too light to sink passes on to the next classifier, where the water pressure and discharge spigot are regulated to permit a further classification. Additional water is added through a circular chamber surrounding the bottom of the sorting column. This equalizes the pressure due to the height of the column and enables the classifying water to work without interference from counter currents.

These classifiers require only a small quantity of water, which is a consideration at the Frontenac mill. Further, they are not easily choked with foreign matter, nor do they permit the accumulation of a bank of solids at the top which, by becoming suddenly dislodged, may fall into the sorting column in a mass and escape classification.

Taking up the flow of ore from the last trommel, it passes to a thickening box, the overflow of which goes to the slime department and joins the tube mill discharge. The thickened underflow passes to three Flood classifiers, which give three classes of sand pulp and a fine overflow. These four products are treated on seven Card tables, each classifier discharge on two tables and the fine overflow on one.

Fig. 3 shows this section of the mill. This set of tables makes

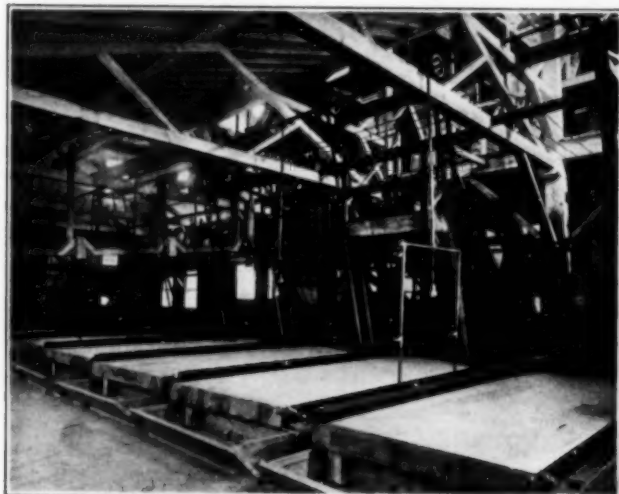


FIG. 3.—VIEW OF CONCENTRATING FLOOR FRONTENAC MILL, BLACK HAWK, COLO.

two concentrates, lead and iron. The former is rich in gold which has been liberated from the pyrite, while the latter carries some of the copper mineral, the specific gravity of which approaches that of pyrite. The slimes and middlings from these tables are retreated as shown in the flow sheet, the coarsest being first reground in tube mills with the fine jig tailings.

The use of the tube mill as a regrinder of middlings is still new in practice, although the idea seems to have been accepted as sound. By regulating the various elements which contribute to the net result it seems possible to get a wide range of products from the tube mill. Consistency of pulp, quantity of pebbles, size and speed of the tube can be so regulated as to make the mill adaptable to comparatively coarse grinding for concentration or to fine grinding for agitation in cyanide solution.

The tubes at the Frontenac mill, shown in Fig. 4, are 6 ft. x

12 ft. in size and are run at a speed of 21 r.p.m. They have sillex lining and carry a load of about 7000 lb. of Norway pebbles. Only one tube is now in operation, and it is grinding about 60 tons of solids in 24 hours. The tube feed, as already stated, is the tailings from the jigs treating $-6 + 10$ -mesh pulp and coarse middlings from the Card tables. The tube product is about 40-mesh material, with only a small percentage of -100 -mesh. The machines have not been in regular operation long enough to give average screen analyses of the product.

The combined slimes and reground middlings are elevated, as shown in the flow sheet, to pulp thickening boxes, the underflow of which is classified in six Flood classifiers for



FIG. 4.—TUBE MILLS USED FOR REFINING TABLE MIDDINGS AND JIG TAILINGS, FRONTENAC MILL, BLACK HAWK, COLO.

treatment on 10 Card tables. The overflow of the thickeners is further thickened in three 8-ft. Callow tanks for treatment on three Deister No. 3 slime tables.

Fig. 5 gives a view of the Callow tanks, with tube mills in the pit in the background, Card tables on the right and Deisters on the left. Owing to temporary water shortage the overflow of the Callow tanks is further clarified in thickening boxes and used for table wash water. The tables in this section make but one class of concentrates, practically all the galena having been removed in the jigs and coarse tables. Fig. 6 gives a view of part of the first division of the slime department.

Retreatment of the middlings from the Card and Deister slime tables is accomplished on additional tables of the same kind on a lower floor. These also make but one concentrate, which is richer in copper than the others owing to the naturally fine state of the copper mineral and its tendency to form slime.

Assays.

The following table gives average assays of the five classes of concentrate. It will be observed that the silver is nearly uniform throughout. Practically all the lead is removed in the jigs and first set of Cards, while the copper is recovered principally in the slimes. Each class is shipped separately on account of the varying percentage of silica which, according to smelter contracts on concentrates, is subject to a penalty when it exists in quantities above, say, 15 per cent.

	Gold oz. per ton.	Silver oz. per ton.	Lead per cent.	Copper per cent.	Silica per cent.
Jig concentrate	0.70	12.00	10.00	1.20	10.00
Card iron concentrate.....	0.60	11.00	.....	2.00	9.00
Card lead concentrate.....	5.00	12.00	37.00	.....	.....
First slime department....	0.45	12.00	.....	3.00	20.00
Second slime department..	0.40	12.00	.....	3 to 4	30.00

The ratio of concentration is 4:1, and the percentage recovery, figured on shipments, is 85 per cent on gold, 78 per

cent on silver, and 75 per cent on lead and copper. This compares very favorably with recoveries of 70 per cent on gold and 60 per cent on silver when the same ore was treated by stamp crushing to 20-mesh and simple concentration in the Iron City mill.

Power and Water.

The mill building is of frame construction, steam heated and electric lighted. Electric power is received from the lines of the United Hydro Electric Power Company, Georgetown, Col.



FIG. 5.—CALLOW THICKENING CONES SHOWN IN RELATION TO TUBE MILLS AND ELEVATOR, FRONTENAC MILL, BLACK HAWK, COLO.

Six General Electric 440-volt induction motors are distributed as follows:

50 hp for crusher and elevator.

100 hp for three sets of rolls and two elevators.

25 hp for three double jigs, six trommels and seven Card tables.

20 hp for 13 Card and 5 Deister tables.

75 hp for two tube mills and elevator.

15 hp for Deming three-plunger pump, size 9 in. x 10 in.

The total power requirement has been found to be 176 hp at peak load and 150 hp on running load.

Water is obtained from Clear Creek, but can be used only after passing several settlement basins for the removal of sand and slime. It is then pumped to storage reservoirs on the hillside. Good water supply is a problem in this district, but the Frontenac company is making arrangements for an independent supply, which will be available probably this year.

The mill has been in operation since the middle of February, and at the time these notes were obtained had been running only five or six weeks. Hence it has been impossible to present some data, such as screen analyses, etc., which will be available later when those in charge have time for such details. Enough has been presented, however, to show a marked departure from former milling methods in this district, and acknowledgment is due to Mr. Lowe, Mr. Tyler and Mr. Fitzgerald for courtesies extended and information given for publication.

The Determination of Manganese in the Presence of Chromium and Tungsten.

By THOS. C. WATERS.

The accurate determination of manganese in high-speed and air-hardening tool steel, or in any alloy steel containing chromium, has given the metallurgical chemist considerable trouble, both in the volumetric and color methods, owing to the fact that in oxidizing the manganese to permanganic acid part of the chromium present is oxidized to chromate and has an action similar to that of the permanganate upon reducing agents used in volumetric determinations and in the color method the yellow color of the chromate interferes with the pink produced by the manganese and destroys its accuracy. We are

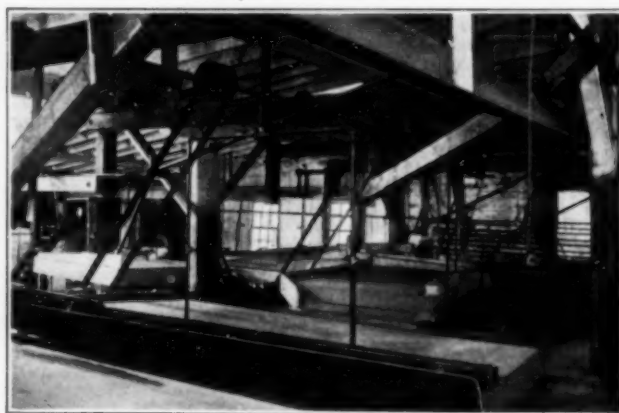


FIG. 6.—SLIME CONCENTRATING DEPARTMENT, SHOWING CARD AND DEISTER TABLES, FRONTENAC MILL, BLACK HAWK, COLO.

using a method in our laboratory which is a combination of the Volhard and bismuthate methods and are inclined to think the application original.

Two grams of drillings are dissolved in 20 c.c. of sulphuric acid (1.2 Sp. Gr.), enough water being added from time to time to keep the iron sulphate in solution. The solution when complete is oxidized by adding 5 c.c. of nitric acid (1.42 Sp. Gr.) and then evaporated until fumes of sulphuric acid are given off and the carbonaceous matter is destroyed; 100 c.c. of water are added and the solution of the ferric sulphate effected by boiling. The liquid and residue are washed into a graduated 500-c.c. flask and a solution of sodium carbonate added until the solution becomes dark in color and the precipitate formed by the addition of the carbonate dissolves with difficulty.

An emulsion of zinc oxide and water is then run into the flask a little at a time and the flask shaken after each addition until all the iron and chromium have been precipitated. The volume is then made up to 500 c.c. with water and the precipitate allowed to settle; 250 c.c., equivalent to 1 gram of sample, of the supernatant liquid is decanted, through dry filter and transferred to an Erlenmeyer flask. The solution is acidified with 25 c.c. of nitric acid (1.42 Sp. Gr.) and one gram of sodium bismuthate added.

It is well to shake the flask for several minutes after the addition of the bismuthate and then allow the residue to settle for a few minutes, after which it is filtered through asbestos, the filter pump being used. The flask and filter are washed with water containing a little nitric acid until free from the pink color of the permanganic acid. The filtrate is transferred to a beaker and a measured volume of ferrous sulphate solution, in excess of the permanganic acid, is dropped into the solution to reduce it. Its excess is titrated with a standard solution of potassium permanganate until a delicate pink color is obtained.

The ferrous sulphate solution should be made equivalent in strength to the permanganate. The difference between the num-

ber of c.c. of ferrous sulphate solution added and the number of c.c. of permanganate used to titrate the excess will give the number of cubic centimeters of permanganate which are equivalent to the manganese in the steel. By multiplying the number of c.c. of permanganate found by its manganese value the weight of manganese in the sample is found.

A solution of convenient strength for steel of low manganese content is made by dissolving one gram of potassium permanganate to a liter of water. It is standardized in the usual way, either with iron wire or ammonium ferrous sulphate, to find its exact value per c.c. in iron. Its iron value multiplied by the factor 0.1968 gives its value in manganese.

The ferrous sulphate solution may be made of such a strength as to exactly equal the permanganate solution, or, if not quite equal in value, a blank titrate is made and its value in c.c. of the permanganate solution found. Fifty c.c. of sulphuric acid to the liter will keep the ferrous sulphate from crystallizing out of solution.

I trust that this method of determining manganese in the presence of chromium may prove of value to others who desire to combine accuracy with reasonable speed, as it has to me.

*Columbia Tool Steel Company,
Chicago Heights, Ill.*

The Grinding and Screening of Clays.

The inherent difficulties in grinding and screening substances of a clayey nature have given rise to the development of machinery specially adapted to this purpose. The success of these machines in the various branches of the clay industry has led to their adoption also in some metallurgical plants where the conditions are exceptional and where the usual devices are not applicable. There has just been issued by the Geological Survey of Ohio *Bulletin No. 11*, entitled "The Manufacture of Roofing Tiles," by W. G. Worcester and Edward Orton, Jr., containing the latest data on actual practice in grinding and screening clays, from which we take the following excerpt:

The purpose in grinding clays preliminary to manufacture by the plastic process is twofold: First, to break up any obnoxious minerals which occur in coarse size and disseminate them through the mass; and, second, to create plasticity in clays in which that property lies dormant or undeveloped. While both purposes are probably accomplished in grinding any given clay, only one may be, and usually is, in view. Thus in soft, plastic clays there is need only of crushing and disseminating mineral impurities, while in homogeneous shales the principal requirement is the development of plasticity.

Grinding is practised both wet and dry. Wet grinding is used where defective plasticity is found, as it is the best known method for developing latent plasticity; but at the same time the method is inefficient in securing physical homogeneity. Hence this treatment is usually applied to hard shales and fire clays. In general, dry grinding is practised where the material is unhomogeneous naturally, and where its lack of homogeneity would cause trouble if not overcome. It is followed ordinarily by screening, which establishes the limit of size of the particles and insures uniformity. The dry screened clay is then converted to the plastic state by a subsequent process.

Thus it is seen that the wet and dry grinding processes are more than alternative routes to the same goal. The choice of treatment lies mainly in the judgment of the operator. The wet treatment is slower, more costly, and has less control of the homogeneity of the product, but produces far the best plasticity. In general any clay can be treated by this method, but it is uncommon to use save where necessary for the reasons given. The dry treatment is faster, cheaper, produces a more homogeneous paste, but of deficient plasticity. It can be

used with clays of good or moderate plasticity, and wherever possible will be used for the reasons given.

The following observations on machines are from actual installations in roofing tile plants in the United States:

Rolls.—The roll is one of the simplest and oldest forms of grinding machines. Essentially it consists of two cylinders or cones whose surfaces are in close contact or held closely parallel to each other. Their axes must be in the same plane, and in the case of cylindrical rolls are parallel, but in the conical rolls the axes are inclined to each other by an amount proportional to the taper of the cones. Rolls are designed for two different ends: First, as a wet grinding machine for crushing stony, plastic clays, and for rejecting the rocks or hard portions which are too large to fall within the angle of nip; second, as a dry grinding tool for pulverizing large quantities of nearly uniform size of grains. The commonest use of rolls in this way is as a tailings grinder to finish the grinding of small particles which are partly reduced, but not enough so to pass the screens.

Wet Grinding Rolls.—At the plant of the Detroit Roofing Tile Company, Detroit, Mich., differential rolls are used for grinding a fine grained alluvial clay which is so plastic as to be difficult to grind in a strictly dry grinding machine like a dry pan. One roll is small and driven at a high speed, and the other is larger, driven at lower speed. They are set within a fraction of an inch of each other. The small roll, about 9 in. or 10 in. in diameter by 2 ft. long, runs at approximately 500 r.p.m., while the large roll, about 18 in. in diameter, makes but 150 r.p.m. The peripheral speed of these two rolls is quite different, so that when clay is fed into the machine it not only squeezes and crushes it, but also shreds and tears it apart as well. This machine is able to take clay either dry or wet and carry it through. As the clay falls from the rolls it is put through a pug mill and stored in aging bins. At another plant both rolls are of the same size, 2 ft. long and 30 in. in diameter, running at the same speed. These rolls also are followed by a pug mill, the combination being admirably suited to the needs, which are principally a thorough mixing of the different layers as they come from the pit and a thorough incorporation of an added ingredient which is foreign to the clay itself.

Dry Grinding Rolls.—The grinding of glacial clays presents a problem not found in alluvial clays and shales on account of the occurrence of boulders, gravel, sand, etc., which have been picked up by glacial action. Glacial clays are thus very heterogeneous in character, and their preparation offers a special problem. At one plant treating this kind of clay a pair of conical dry crushing rolls, smooth surface, set 1 in. apart, and running at 75 r.p.m., handles about nine tons per hour. In size they are 2 ft. long by 12 in. at the large end and 7 in. at the small. These rolls crush the lumps of clay and smaller pebbles; any stones that are too large for the angle of nip gradually work their way to the large end of the cones, where they fall out into a wheelbarrow and are removed. The use of these rolls is chiefly for their qualities as stone separators, but the next step in the process would hardly be successful if the clay had not first been crushed and shredded.

Dry Grinding Pans.—No other tool wholly takes the place of this as a rough-and-ready grinder, in which the material comes to it in widely varying sizes, degrees of hardness, degrees of plasticity and in rates of feeding. Irregularities in all these points may occur in any works and on every dry pan. No machine that cannot give a good account of itself under such conditions will ever displace the dry pan as a clay-grinder's main reliance. The step bearing which carries the weight of the vertical shaft is one of the most essential features about a dry pan. Usually a load of five to ten tons is carried on a bearing not as a rule exceeding 5 in. in diameter. This bearing tends to heat very easily and unless proper oiling facilities are provided it will be very short-lived. The principal thing is to secure positive and copious lubrication. Nearly

any step, if of adequate size, will stand well if kept thoroughly lubricated and clean. In selecting a pan one should try to secure one that is strongly and well built. By this is meant one that has every joint and bearing planed and fitted, every bolt hole drilled and machined bolts that properly fit the holes. There is not another machine about a clay plant that is expected to stand the rough usage that the dry pan is called upon to endure. It is entirely impossible to say that all the virtues are found in any one design, and there is no best pan in the sense of one filling all situations best.

Disintegrators.—A method of grinding not used in any other roofing tile plant in this country is found in the works of the National Roofing Tile Company, Lima, Ohio. Here a Williams pulverizer is used. The machine is not uncommon in other branches of industry, such as coal and cement. It consists of a horizontal shaft to which are keyed a series of disks, through the circumference of which bars are run, and on the latter are hung swinging hammers, which, by centrifugal force, fly straight outward on a line from the center of the shaft when the machine is rotated at high speed. The hammers strike a very powerful blow, but not being rigidly fixed are free to move backward when they encounter a body heavy enough to overcome the centrifugal force. Clay being subjected to such severe treatment as this is completely broken up before leaving the machine. It is found advisable to bring the clay to the disintegrator as dry as possible, and even then provision is made to steam-heat the jacket of the mill in order to prevent the clay from packing in it. For clays of a hard, compact nature, this machine will unquestionably break up massive lumps and reduce the whole to a powder, but if the clay be fat and sticky it would be impossible to work it in such a machine.

Screening.—After a clay has been through a pan or equivalent, and is in the form of a coarsely granulated powder, the screening still remains difficult if the moisture exceeds 5 per cent or 6 per cent. Caking on the screen, covering the holes, agglomerating and rolling on the surface without passing through, sticking in elevator cups, choking spouts and runways are troubles incident to dry clay screening.

The purpose of screening is to set a limit on the maximum size of particles. As the coarsest particles in a ground mixture also are likely to be the hardest, and also of different chemical composition from the matrix of fine aluminous material, it follows that these coarse particles are both difficult to grind finer and are the most injurious to the clay if not re-ground and made to blend well into the matrix. Screening is therefore necessary to establish a limit beyond which particles cannot enter the clay body except by accident. It is a very necessary part of the process of homogenization, of which grinding and tempering are the two principal steps.

On account of the troublesome nature of clays in the screening process, the actual size limit in clay plants is often much greater than is desired by the manufacturer, because without predrying he cannot either grind or screen effectively. Roofing tile clays in general are passed through from 12-mesh to 20-mesh screens or equivalent. Some form of the inclined screen, either stationary or movable, is most generally used.

Stationary Inclined Screens.—These consist of an inclined chute, the bottom of which is covered with punched plate, over which the pulverized clay passes. The size of the perforations and the angle at which the screen is hung govern the size of grain that will pass through it. Should the screen be horizontal particles the same size as the openings would pass, but upon elevating one end the particles attain a momentum and those passing through will be smaller and smaller as the angle of elevation increases. Hence, inclined screens are made adjustable as regards angle of elevation.

The fixed inclined screen gives considerable trouble through its tendency to blind, especially when the clay is damp. This means constant attention to secure effectiveness. Only one roofing tile plant in the country is using the fixed screen, and

the material is a mixed sandy clay, screened through a 16-mesh screen, which is a little coarser than the average mesh used in this work.

Piano Wire Screen.—A recent form of inclined screen is made of heavy steel piano wires, strung on a strong substantial iron frame about 30 in. wide by 6 ft. long. The wires are drawn to a high tension and provision is, or should be, made to prevent slipping. At each end of the frame the wires are drawn over a rod threaded to suit the space required between the wires. By varying the pitch of these threads the mesh can be changed. The constant rigidity of the wires is an important requirement in order to insure regularity of the product. When properly constructed and kept in condition this screen has large capacity, does not bind easily, requires no power and little head room. In the roofing tile industry it has been found that on soft, easily slaking shale good results are obtained, while on hard, sandy shales the results are not all that could be desired.

The principal trouble lies in keeping the wires rigid enough to give a uniform product.

Traveling Inclined Screens.—The main difference between this and the stationary type is that the screening surface is composed of punched metal plates, constantly in motion on an endless chain. The object of the device is to bring automatically every part of the screen surface over a rotary cleaning brush, instead of depending on its being done by hand, as is the case with stationary inclined screens. The moving screen is made up of sectional screen plates, attached to sprocket chains on each side. These chains travel upward on the frame, over sprocket wheels at the top and down on the under side. A spreading board at the top delivers the clay onto the screen, after which it slides down over the plates which are moving in the opposite direction. Particles of proper size drop through the screen and the larger tailings flow over the end to be re-ground.

The screen plates may be made of piano wire or screen cloth instead of punched plates, if desired. The entire screen is hung so that its inclination can be changed in a few minutes. The rate of travel is not over 3 ft. or 4 ft. per minute. There are a number of advantages in this type of screen over others; it requires almost no attention, has a large capacity and will screen finer clay because it is always clean.

It has been found quite successful in screening ore as well as clay.

Centrifugal Screens.—One of these devices is in use at a plant at Alfred, N. Y. It consists of a large funnel-shaped receptacle, 4 ft. high, with a diameter of 9 ft. at its upper or large end. The screen is supported on a central shaft with spiders and suitable bearings at top and bottom, and revolves with the shaft. Clay is fed into the center of the rapidly revolving cage, and upon striking the bottom of the cone begins to move up the sloping sides of the cone by centrifugal force. The fine clay passes through the perforations, while the coarse material is carried up and over the top, whence it is returned to the rolls for regrinding.

It is claimed that this screen is giving excellent satisfaction in practice.

Visit of Pittsburg Railway Club to Ellwood City Works National Tube Company.—On Friday evening, April 28th, at the monthly meeting of the Pittsburg Railway Club, Mr. F. N. Speller, metallurgical engineer of the National Tube Company, read a paper on locomotive boiler tubes. In the afternoon of the same day the National Tube Company had invited the Pittsburg Railway Club to visit the Ellwood City plant where the members of this club had an opportunity to observe the manufacture of Shelby cold drawn steel tubes and Shelby hot rolled seamless steel tubes. The party was taken to the works by special train and luncheon was served going, in two large baggage cars. All members of the Pittsburg Railway Club had been invited.

Improvements in Cotton Bleaching.*

By WALTER S. WILLIAMS.

Textile Expert, Arthur D. Little, Inc.

Bleaching is the whitening or removing of color from a substance, but in the textile industry the term is broadened to include the removal of all foreign bodies and coloring matter adhering to or included in the original fiber. In the case of fabrics it also covers the elimination of all materials, such as starch, oil and the like, added either intentionally or accidentally in the process of manufacture.

Cotton was used for the production of cloth thousands of years before the Christian era, and bleaching of the fabrics so made must have been more or less crudely performed even at that early age. While interesting, the scope of this paper will not permit the tracing of the early history of the art. Ancient processes will therefore be cited only as they may have some bearing upon modern practice.

An efficient process of bleaching requires a thorough understanding of the nature and chemical composition of the fiber and of the substances to be removed, as well as a knowledge of the effect produced by the different agents to be employed. It is a remarkable fact that very few complete studies of the process as a whole exist, and that the few careful investigations of different steps in the procedure have not received the attention and consideration they deserve at the hands of the practical manufacturers. There is no doubt that great progress will be made in the improvement of both processes and results by careful and scientific research in this field.

At the very outset of our study we are met by the fact that the chemistry of cellulose, which composes 83 per cent to 90 per cent of the crude cotton fiber, is still, after many years of investigation, far from being clearly defined. Two series of analyses conducted by the Department of Agriculture gave average results as follows:

FERTILIZING CONSTITUENTS.	
Water	6.07
Ash	1.37
Nitrogen	0.34
Phosphoric acid	0.10
Potash	0.46
Soda	0.09
Lime	0.19
Magnesium	0.08
Ferric oxide	0.02
Sulphuric acid	0.6
Chlorine	0.07
Insoluble matter	0.05

PROXIMATE CONSTITUENTS.	
Water	6.74
Ash	1.65
Protein	1.50
Cellulose	83.71
Nitrogen-free extract	5.79
Fat	0.61

ASH FROM COTTON.	
Potassium carbonate	44.8
Potassium chloride	9.9
Potassium sulphate	9.3
Calcium phosphate	9.0
Calcium carbonate	10.6
Magnesium phosphate	8.4
Ferric oxide	3.0
Alumina and loss	5.0

Similarly, the precise change produced by alkalies and acids

has not been determined and the extent to which such treatment may be carried without injuring the strength and lasting properties of the fabric is now rather a matter of observation and practical experience than an actual science.

For a knowledge of the impurities present in crude cotton we are indebted to a study of these bodies by E. Schenck. About 5 per cent of the original fiber is removed by boiling in soda ash for eight hours and may be thrown down from the resulting dark-brown liquor as a copious, light-brown precipitate by adding an excess of dilute sulphuric acid. If dried, it produces a brittle, horn-like mass which leaves upon incineration an ash varying from 2.3 per cent to 6.9 per cent.

From this residue Schenck succeeded in isolating substances which he classifies as follows:

1. A wax-like body which he named *cotton wax*. It is lighter than water, is soluble in ether and alcohol, but insoluble in water and only slightly dissolved by boiling dilute caustic soda.
2. A *fatty acid* which melts at 55.5° C. and may be either margaric or a mixture of stearic and palmitic acids.
3. Two nitrogenous, amorphous, brown *coloring matters*, one of which is easily soluble and the other sparingly soluble in alcohol.
4. *Pectic acid*, obtained in the form of a light-yellow amorphous substance resembling gum or gelatine. This body forms much the larger part of the precipitate, the other constituents being present only in extremely minute quantities.
5. Albuminous matter.

Many others have studied more or less thoroughly the nature of the substances extracted by water, ether or other solvents, as well as the nature of the ash present in the raw cottons, but without more definite results.

In cotton bleaching we are confronted with the problem of the removal of these various impurities and of the decolorizing or whitening of any yellow or brown tint still remaining. Broadly speaking, the process consists of boiling with alkali liquors to remove all impurities made soluble by such treatment and a subsequent oxidation for the removal of residual tint.

Cotton may be bleached in almost any form from loose or raw cotton to cotton piece goods, the difference in treatment required in each case being purely mechanical. As the bleaching of cotton piece goods far exceeds the importance of the bleaching of any other form of cotton, we will confine our attention to that form. We will also assume in the succeeding remarks a knowledge on the part of the reader of the terms and processes of practical bleaching.

The complete process used with slight modifications for the past 50 years may be outlined as follows:

1. *Singeing*.
2. *Gray Wash*.—Wet out in washing machine, allow to lie for 24 hours and wash.
3. *Lime Boil*.—Pass through milk of lime and boil for 12 hours under pressure.
4. *Lime Sour*.—Wash and pass through hydrochloric acid at 3° Twaddle, squeeze and allow to lie in sours for six to eight hours. Wash thoroughly.
5. *First Lye Boil*.—Boil six to eight hours with soda ash and resin soap. Wash in kier and through washer.
6. *Second Lye Boil*.—Boil in kier as for first boil, using soda ash and a small amount of caustic. Wash in kier and through washer.
7. *Chemic*.—Pass through hypochlorite of lime solution at ½° to 1° Twaddle. Allow to lie in chemic from six to eight hours.
8. *Sour*.—Wash and pass through sulphuric acid at 1° to 2° Twaddle.
9. *White Wash*.—Wash until all traces of acid are removed, open and dry. This process in practice will occupy from five to ten days.

The first step in the process of bleaching cloth for printing or other purposes requiring a smooth face is the operation of singeing, which has for its object the removal of all loose

*Presented before the Congress of Technology at the Fiftieth Anniversary of the Granting of the Charter of the Massachusetts Institute of Technology.

hairs from the surface of the cloth. This step is largely mechanical, but requires close attention to produce satisfactory results without damage to fiber or undue cost for gas or fuel. The most approved method, known as gas singeing, passes the fabric at speed several times through the flame of Bunsen burners extending the width of the cloth. Improvements in this step must come from proper regulations of the gas mixture and mechanical arrangement of rollers and speed of travel to produce the most efficient results.

The next operation is known as steeping, or gray washing, and consists in passing the goods through a washer or otherwise saturating, preferably with warm water, and allowing it to remain piled in a warm room from 18 to 24 hours. This treatment removes any bodies soluble in water and, as a result of fermentation, the starchy matters added as sizing.

Modern practice has made the mistake of considering this operation unnecessary and omitting it entirely even when the caustic boil is used. Lime probably removes the starchy matters completely, but it is extremely doubtful if more than a relatively small portion is extracted in the caustic boil. Steeping may be replaced by a malt treatment, using by preference one of the diastase preparations now on the market. The solution is prepared by using 15 lb. to 20 lb. of diastase or similar product to 100 gal. of water and warming to 140° Fahr. to 150° Fahr. The goods are wet out in this solution and the action allowed to continue for 15 to 30 minutes, then washed and passed to the next step in the process. Solubility of the starch may also be produced by wetting out with very dilute hydrochloric or sulphuric acid and piling for a short time. This process must be carried out with extreme care, owing to danger of the acid injuring the fiber.

Lime Boil.—The cloth is saturated with milk of lime of such a strength that it takes up about 4 per cent of its weight of CaO, run into one of the standard kiers and boiled with constant circulation of the liquor through the goods. This operation decomposes the fats and similar matter contained in the cloths and forms as a result insoluble lime soaps. These latter are broken up by the scouring which follows and completely removed by the subsequent operations. In addition, the other natural impurities of the raw cotton, as well as starch, are so changed that they either become soluble or are more easily acted upon by the chemicals employed in the succeeding processes.

The gray sours remove the excess of lime and other metallic oxides, if present, besides breaking up the insoluble soaps formed on the fiber.

The lye boils continue the reactions already begun in the lime boil and further saponify and remove any fatty acids resulting from the decomposition of the lime soaps in the previous steps.

Resin soap is employed by some bleachers and is supposed to remove certain indefinite constituents of the fiber which are said to have a deleterious effect on the whites of prints and are not fully removed by the other agents employed.

Bleaching or Chemicing.—The destruction of the coloring matter now left in the fabric is the object of this final step. Previous to the nineteenth century this was always accomplished by the exposure of the moist cloth to the action of air and sunlight, and extensive bleaching greens formed an important part of every establishment. The use of chlorine for this purpose was first proposed by Berthollet, about 1785, but its use even after the introduction of the hypochlorite of lime was very slow in becoming general. To-day, chlorine, either as calcium or sodium hypo, far exceeds all other agents in importance and in amount used. With proper regulation of strength of solutions and duration of action this bleaching agent may produce the most satisfactory whites without appreciable injurious action on the strength or other desirable properties of the fiber.

Large quantities of chlorine are annually produced electrolytically either as a gas to be absorbed by lime to form ordinary bleach or as hypochlorite of soda solution to be used direct.

On a large scale the latter form cannot compete successfully with the cheaper and more common product, but it finds extensive use in laundries and in small establishments.

The sodium hypochlorite solution as made in this form of apparatus contains an excess of sodium chloride which causes the chlorine to be given off freely either to the fabric or the atmosphere. The solutions are, therefore, unstable and cannot be made in advance. The cost of production is also higher except in the case of cheap electric power and low freight rates for salt.

The much-claimed superiority of electrolytic bleach seems to have been based on the increased rate at which the chlorine was given off in the presence of the chloride and may be produced, if desired, in bleach from other sources.

The use of hypochlorite of soda made from bleaching powder and soda ash is highly to be recommended and in many cases will more than repay the increased cost. The following receipt for its manufacture is given by Thies and Herzig:

Two hundred and ninety kilograms of bleaching powder of 33 per cent available chlorine are ground to a paste with 1100 liters of water, and to this are added 175 kg of soda ash dissolved in 500 liters of water, and the resulting solution is immediately made up in 2000 liters. After stirring for one-half hour the mixture is allowed to settle over night and the clear liquor is decanted. The sediment is mixed with clear water, the clear liquor being decanted and this process repeated until in all 5000 liters of liquor are obtained, which should stand at from 6° to 6½° Twaddle. This solution is alkaline and is said to keep well.

In order to neutralize the free alkali and start the liberation of the hypochlorous acid, sulphuric or hydrochloric acid is added to the liquor just before using. Thies and Herzig recommend 6 grams to 7 grams of sulphuric acid of 60° Beaume for every 10 liters of the above bleaching liquor.

The kiers used in bleaching have had much to do with the progress of the art. Starting from open kettles heated by direct fire the natural tendency led to a large open kier, but heated by steam. A great improvement in this kier was the introduction of a central vomit pipe taking the liquor from the bottom of the kier and throwing it by means of a steam ejector over the goods at the top, thus producing a circulation through the goods. The next improvement was the introduction of the closed kier, by means of which the pressure and consequent temperature of boiling was increased.

The first distinct system was that of Barlow, whose kier was introduced about 1870. This system employs two kiers working in pairs and may use steam up to 40 lb. pressure. The liquor circulates from the bottom of one kier to the top of the other. In working with the Barlow system both kiers are filled with cloth as usual, the requisite quantity of liquor admitted and steam blown through both to expel the air through vent pipes. The kier is then closed and steam let into one only, so that the pressure at the top forces the liquor through suitable connection to the top of the other, where it is sprayed over the cloth.

When most of the liquor has been forced into the second kier the valves are changed so that the pressure is led to that kier, changing the circulation to the top of the first kier. This reversing process is continued until the goods are sufficiently boiled, when the kiers are blown out, washed and the process continued as usual.

The next great step in advance was the advent of the Mather kier, which was especially constructed by Messrs. Mather & Platt to carry out the process devised by Horace Hoechlin. In this system the lime boil is entirely dispensed with and this, as well as the two lye boils of the old process, are replaced by a single boil in caustic soda and resin soap. The kier used for this boil is a large horizontal cylinder with convex ends, one of which may be removed to allow the entrance of the goods. Suitable means are provided for raising the door and for making the same steam-tight when closed. The pieces to be bleached are piled on wagons made of sheet iron with perforated

bottoms and running on tracks leading inside the kiers. When ready the wagons are run into the kier, the door is closed, the air driven out by steam and circulation started. While the kier is boiling, other wagons may be loaded and those already boiled unloaded, thus increasing greatly the production of a single kier.

The process aims to subject the fabric to the action of caustic liquor and steam at the same time and for this purpose the amount of solution used is small compared with the size of the kier. The circulation is maintained by means of a centrifugal pump, which takes the liquor from the space under the wagon and showers it over the top of the goods. It then percolates through the pieces and collects in the bottom of the kier, where it is heated by closed steam pipes and is again taken up by the pump, which maintains a continuous circulation. The kier may also be heated by the introduction of live steam, but the resulting dilution of the liquor is more objectionable in this than in other kiers.

Several ingenious continuous processes have been proposed for boiling cotton piece goods, but as yet no system of this character has succeeded in prolonging the treatment long enough to produce results comparable with those obtained by the more usual method.

The Thies keir and the process of which it forms a part are the result of long, careful research by Thies and Herzig. By designing the kier in such a manner that no steam comes in direct contact with the liquor and thus avoiding the action due to the oxygen contained in the air always present in steam, it is impossible to use strong caustic at a high pressure without fear of tendering the fabric. The latest form of kier consists of three parts—the kier proper, the vacuum boiler and the superheater. The vacuum boiler consists of an upright cylindrical vessel similar in size and shape to an ordinary kier, while the superheater is of the same height as the kier, but much smaller in diameter. The latter is provided with closed coils for heating. For the circulation and transfer of liquors use is made of a Grindle pump. The boiling consists of two parts and the process is described by the authors as follows:

The goods saturated with alkali (liquor blown off from the previous bowking) are packed into the kier and then by means of the Grindle pump the old kier liquor is drawn from the vacuum boiler (which is quite full to start with, and closed at the top) and sent in at the bottom of the kier until the latter is quite full, the air escaping through a blow-off valve at the top. As soon as the kier is full the air valve is closed.

By pumping the liquor from the vacuum boiler into the kier a vacuum equal to about 10 lb. is produced in the former vessel. A pipe provided with a throttle valve connects the top of the kier with the top of the vacuum boiler. This valve is now slightly opened, so that a circulation of the liquor takes place, while any air contained in the kier rises with the liquor, passes through the throttle valve into the vacuum boiler, where the liquor falls to the bottom and expands into the vacuum.

The pressure in the kier is now gradually increased to three atmospheres by choking the valve, when any air remaining in the goods is mechanically dissolved out of the goods (air being more soluble in water under pressure) and transferred to the vacuum boiler. After the air in the vacuum boiler has been expelled, steam is turned on in the superheater and the bowking continued for two hours at 45 lb. pressure.

The pump is now stopped, the steam turned off and the liquor blown off under its own pressure. Fresh lye, consisting of caustic soda at 6° to 7½° Twaddle and the resin soap, is now run into the kier (which is free from air), the pump set in motion again, steam turned on in the superheater and the bowking proper continued for six hours at 45 lb. pressure.

As free hypochlorous acid is much more efficient as a bleaching agent than any of its salts we find many attempts to make use of this property.

Mather and Thompson pass the cloth continuously through closed chambers in which the pieces are run through an atmos-

phere of CO₂ after being saturated with the ordinary bleaching solution. Acetic acid vapors have also been used in the same manner. The addition of small amounts of sulphuric or hypochloric acid or of acetic or formic acid to the chemic solution will produce similar results, and the improved action of the liquors will be at once apparent.

Chlorine in cotton bleaching may be replaced by other oxidizing agents and will no doubt be superseded at some later date by some agent acting less injuriously on the fiber itself. Such a body is found in sodium or hydrogen peroxides and it is only the higher cost which prevents its more general use. For cotton and silk goods, laces and other special fabrics, it finds extensive application.

Drawing freely from all published information, especially the results of the researches of Koechlin, Thies and Scheurer, the following process has been evolved as a working compromise of the theoretical and practical.

The goods are marked and sewed as usual and piled on trucks. They are then run through the gas singer and directly through a lukewarm solution of diastase or other diastase and into a continuous piling chute—a more or less complicated inclined trough so arranged that while cloth is entering at the upper end and leaving at the lower a large amount of slake cloth fills the length of the incline and allows time for the action to take place. To increase the time of action, several of the chutes may be arranged in series, the cloth passing over a reel between each.

From this step the goods pass directly to a small washer and are then squeezed and piled in a bin. As wanted they are drawn through a saturating machine, where they are impregnated with caustic soda at 3° Twaddle, containing 0.5 per cent sodium bisulphite solutions and packed directly in the boiling kier.

This kier should be of the vertical pressure type with outside vomit pipes and pump circulation. The perforated false bottom should be conical in shape and so arranged as to give a much larger space at the bottom than is usually allowed, and should be provided with both closed and open steam pipes. The closed coil should be sufficient to maintain the kier at boiling during circulation after that temperature has been reached, and must be provided with a suitable trap to remove the hot water and return it to the hot well or feed-water heater.

The goods are evenly plaited and tramped in the kiers by boys in the usual manner to within 2½ ft. or 3 ft. of the top and anchored with nets or chains.

The air is replaced by admitting steam and a charge composed of 3° Twaddle caustic containing 3 per cent of resin soap run in to cover the goods. The kier is brought to a boil with the open coil at a pressure of 15 lb., a small vent pipe being open to allow the escape of air.

When the goods are boiling the open pipe is nearly closed and the boiling is continued for six to eight hours with the use of the closed coil as far as possible.

The charge is washed in the kier, care being taken to prevent access of air to the hot fabric. The pieces are then run out of the kier through a washer, squeezed and returned to another kier, where the boil is repeated, but with the omission of the resin soap.

Experience seems to indicate that two boils are necessary to produce a thorough bleaching without over treatment in the subsequent steps.

The goods are next run through the chemic and piled in open bins for two to six hours. The best results are produced at the greatest economy by the use of hypochlorite of soda prepared as already described, but with experience and care very satisfactory results are obtained by the use of hypochlorite of lime solution at ½° to 3° Twaddle.

Continuous processes which subject the fabric for a short period to a very strong chlorine solution or which sour the cloth after chemicing without previous washing are necessarily injurious to the fiber and unsatisfactory in other respects.

The pieces after lying exposed to the air for a suitable length of time are washed, soured through sulphuric at 1° to 2° Twaddle, washed twice, and are then ready for opening, drying and finishing as desired.

Bleaching to-day is not an exact science and depends for success upon experience combined with close observation and understanding of the various processes. If the heads of the industry in this country could be brought together for an interchange of experience and frank discussion of the most promising lines of research, a great advance would be produced in the art, but in any case we may expect sooner or later more economical and efficient processes to replace many of those now in use.

Boston, Mass.

American Foundrymen's Convention at Pittsburgh.

The annual convention of the American Foundrymen's Association, the American Brass Founders' Association, and the Associated Foundry Foremen will be held in Pittsburgh from May 23 to 26. More than 3000 delegates are expected to attend the convention.

At the same time the great exposition of the Foundry & Machine Exhibition Company will be held. The exhibits will fill more than 40,000 square feet of area.

The Pittsburgh committee in charge of the preparation for the convention has been very active. It consists of Mr. Joseph T. Speer, chairman; Mr. F. W. Zimmers, secretary; Mr. J. S. Seaman, chairman of the Finance Committee; Mr. H. E. Field, chairman of the Convention Committee; Mr. W. A. Bole, chairman of the Excursion Committee; Mr. George P. Bassett, Jr., chairman of the Ladies' Entertainment Committee; Mr. E. D. Frohman, chairman of the Ball Game Committee; Mr. Eliot A. Kebler, chairman of the Reception Committee, and Mr. W. B. Robinson, chairman of the Press Committee.

On Monday, May 22, registration of delegates will be started at the exhibition buildings. The formal opening will be on Tuesday, May 23, and at the joint meeting papers on production cost, economic foundry insurance, and uniform contracts will be presented.

In the afternoon of the same day there will be sessions of the American Foundrymen's Association (papers on unloading methods, on the use of borings in the cupola, on the effect of alloys in cast iron, and on permanent molds) and the American Brass Founders' Association (papers on vanadium in non-ferrous metallurgy, on determinations of nickel in bronzes, on pouring high-grade bronzes, etc).

A joint meeting will be held on Wednesday morning, May 24, with papers on rotary blowers, on foundry construction, on heating and lighting systems, on pattern making, and on molding machines, while separate meetings will be held in the afternoon by the American Brass Founders' Association and the American Foundrymen's Association.

On Thursday morning, May 25, another joint session will be held with papers on molding sand, on the use of alloys, on shot in castings, etc., while for the afternoon a great excursion to foundries and steel works around Pittsburgh has been arranged.

On Friday morning, May 26, separate sessions will be held by the different associations, with election of officers. In the evening of Friday the large official subscription dinner will be held.

Evaporators and Vacuum Pans.

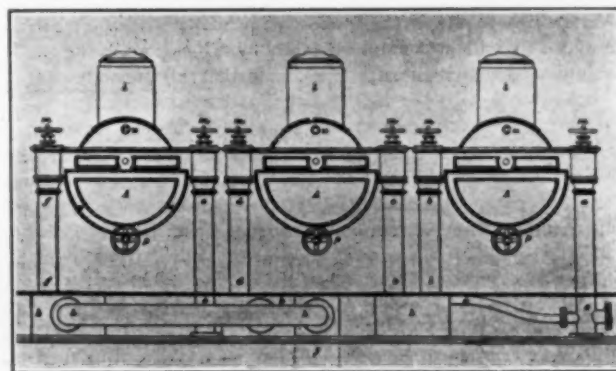
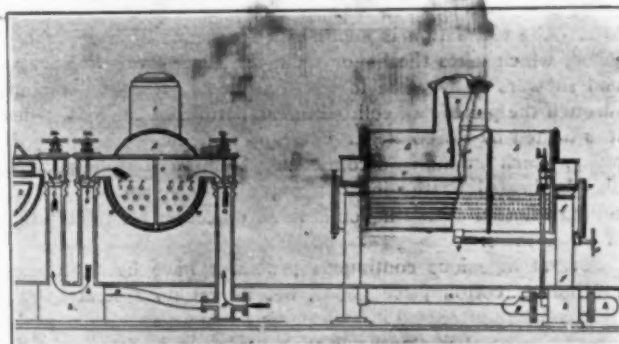
By B. VIOLA, M.E.,

Member American Society of Mechanical Engineers.

(Continued from page 209.)

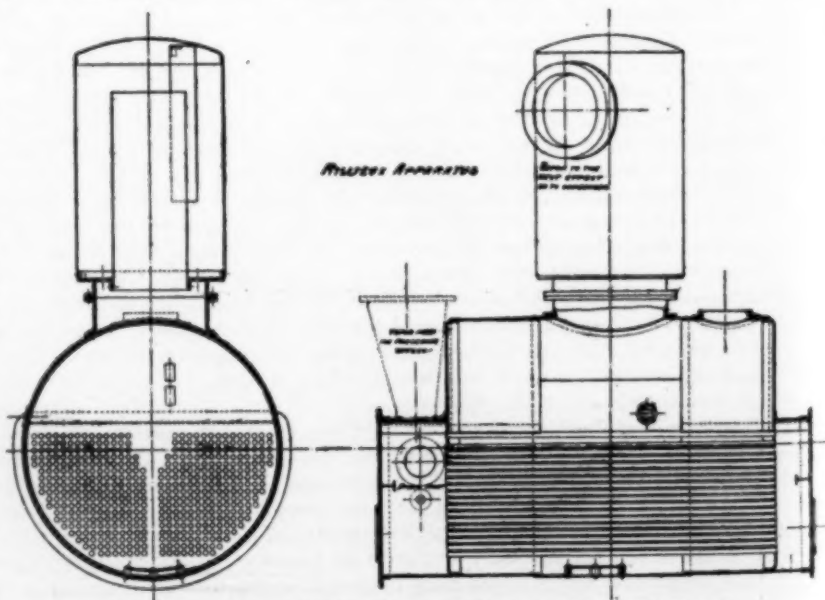
Evaporators with Horizontal Heating Pipes.

The originator of the present system of evaporation was Norbert Rillieux, who in Paris in the year 1830 first proposed



FIGS. 11, 12 AND 13.—ORIGINAL CONSTRUCTION OF RILLIEUX EVAPORATOR.

the construction of the multiple effect evaporator. It took, however, many years before the first one could be built and used by Rillieux himself in Louisiana in the year 1843.



FIGS. 14 AND 15.—MODERN CONSTRUCTION OF RILLIEUX EVAPORATOR.

According to the report to the Thirtieth Congress in 1848 this was a triple effect with wrought-iron heating tubes and

is shown in his original construction in Figs. 11, 12 and 13. It was composed of three cylindrical vessels made of sheet-

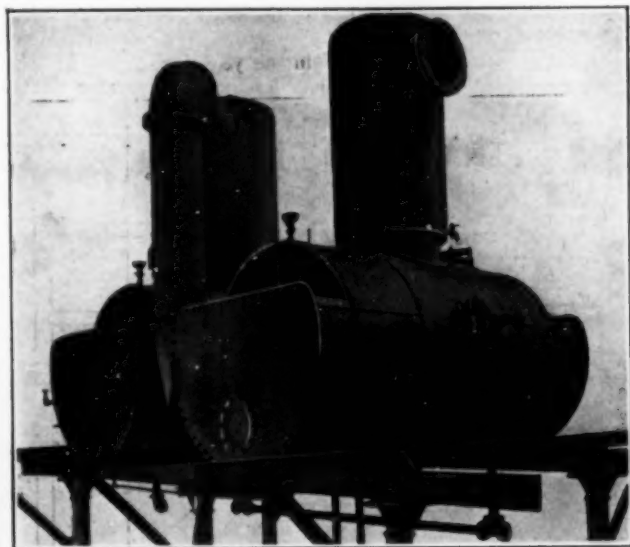


FIG. 16.—DOUBLE-EFFECT RILLIEUX EVAPORATOR.

iron plates 10 ft. long and 3 ft. 6 in. in diameter, made parallel and supported by cast-iron columns which are placed at each end.

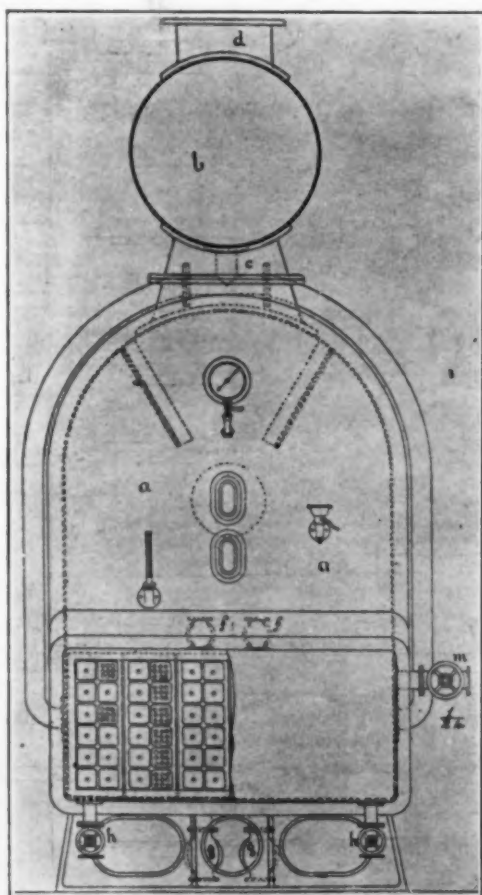


FIG. 17.—JELINEK EVAPORATOR—CROSS-SECTION.

The steam or vapor circulates in the interior and passes from one vessel to the other by means of a system of valves and

pipes and each vessel is provided with a dome in which a cone-shaped connection is inserted for taking up the vapors of the juice and leading it to the next effect. The vapors from the last vessel pass to a condenser, where they are condensed by an injection of water. The vacuum is maintained by means of a large vacuum pump.

A modern construction of a Rillieux evaporator is shown in section in Figs. 14 and 15. Fig. 16 shows a complete double effect manufactured in this country. Rillieux's apparatus was introduced in Europe with the help of his foreman, Brami André, and in 1849 was constructed by Tischbein with horizontal, and later by Robert, in his sugar factory, with vertical heating tubes.

All the evaporators had disadvantages in that the steam chamber and the space for boiling were very small and naturally the surface of the liquid also, especially in the vertical constructions. Under these conditions, when the liquids were in the boiling state,

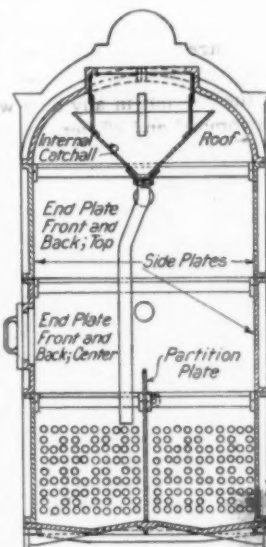


FIG. 19.—SWENSON EVAPORATOR.

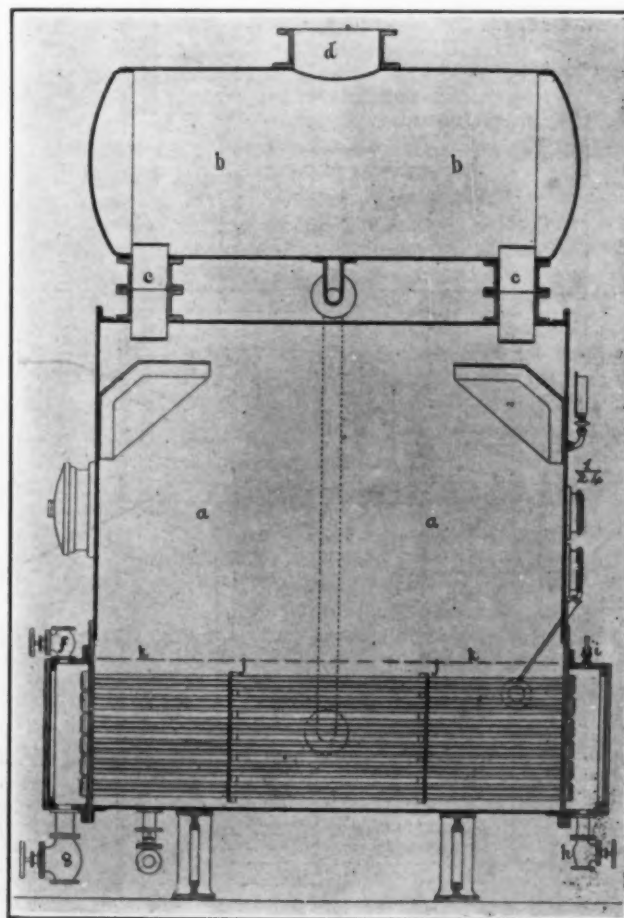


FIG. 18.—JELINEK EVAPORATOR—LONGITUDINAL SECTION.

the vapors carried away great quantities of small drops, thus causing immense loss.

The first improvement to avoid this loss was made by Hugo Jelinek. He constructed his evaporator with a rectangular

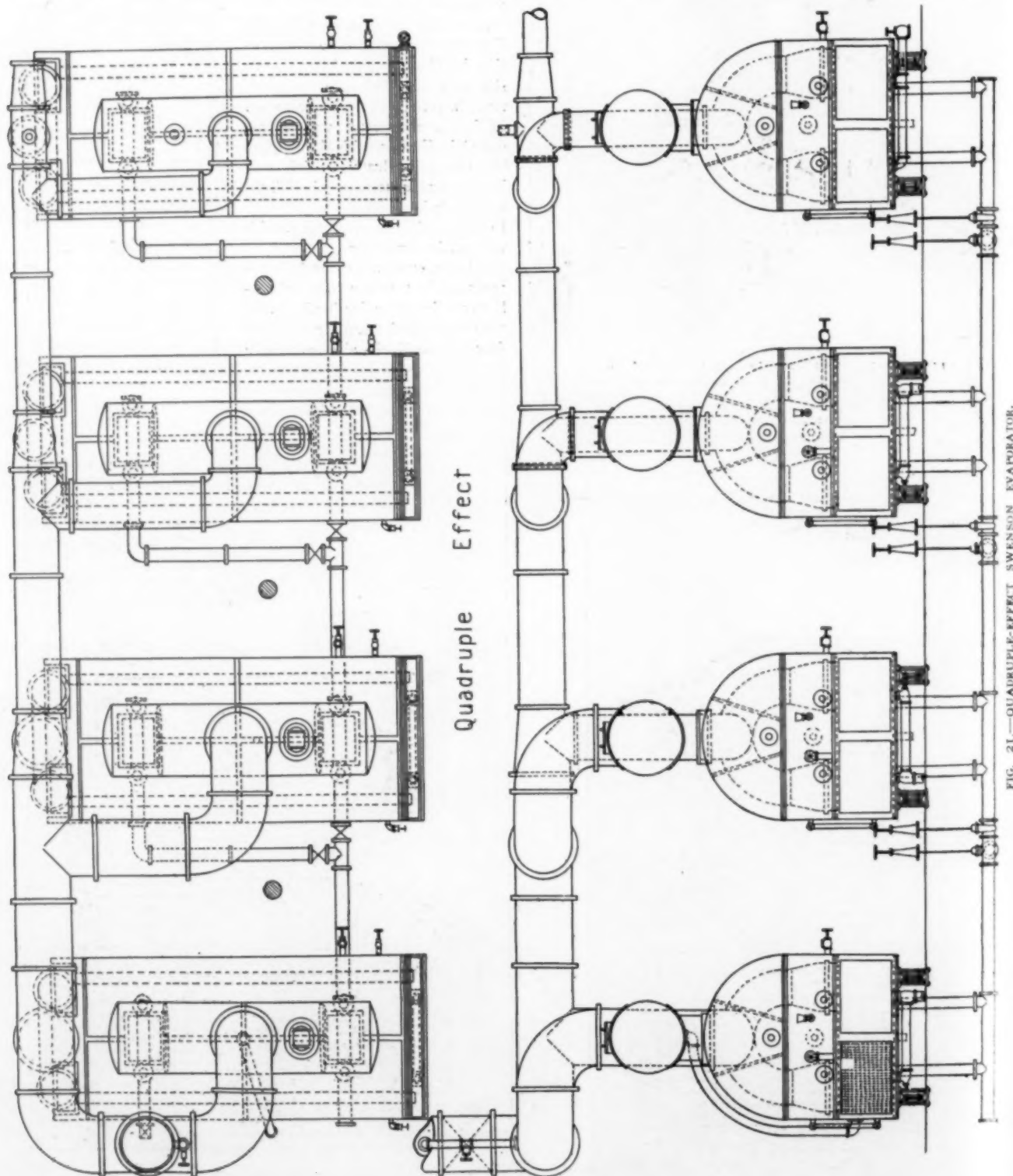
bottom and half-cylindrical top, filling the lower part with a large quantity of heating tubes and making the apparatus very high on account of the large space above the boiling liquid. The liquid was always kept low, hardly covering the heating pipes, and in this way getting a high efficiency, Figs. 17 and 18.

We can see on both sides the so-called drop catchers which prevented the drops raised by the dome vapors to pass in the

A very efficient construction of the Rillieux type is the Swenson evaporator built in the United States and shown in section in Fig. 19. Fig. 20 shows how the heating tubes are made tight to the shells and Fig. 21 the disposition of a quadruple effect.

Film Evaporators.

As mentioned before steam bubbles in an evaporator rise to



T on top of the apparatus. These catchers covered the vapor outlets and the drops raised by the vapors were knocked against them and fell back, the vapors passing out through the two outlets into the next effect or condenser.

the surface with greater difficulty if a large body of liquor covers the heating pipes and naturally the boiling point is much higher in the bottom than at the top. To make the evaporation more efficient different evaporators were con-

structed to let the liquors run on the outer surface or the inner surface of the heating tubes in thin films or fine sprays.

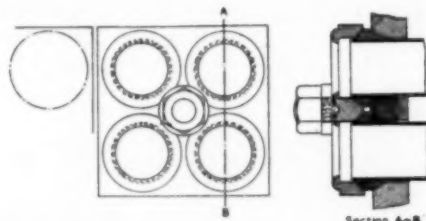


FIG. 20.—ARRANGEMENT OF HEATING TUBES.

We can classify them:

- a. Film evaporators with horizontal heating tubes.
- b. Film evaporators with vertical heating tubes.

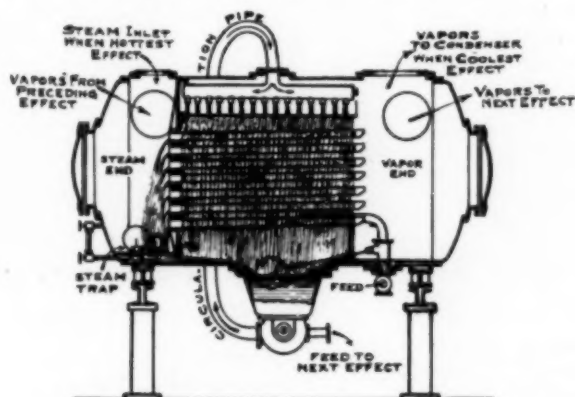


FIG. 22.—FILM EVAPORATOR WITH HORIZONTAL TUBES.

I will describe shortly those most in use at the present time having high efficiencies.

The Lillie Evaporator.

Fig. 22 shows an evaporator with horizontal tubes and

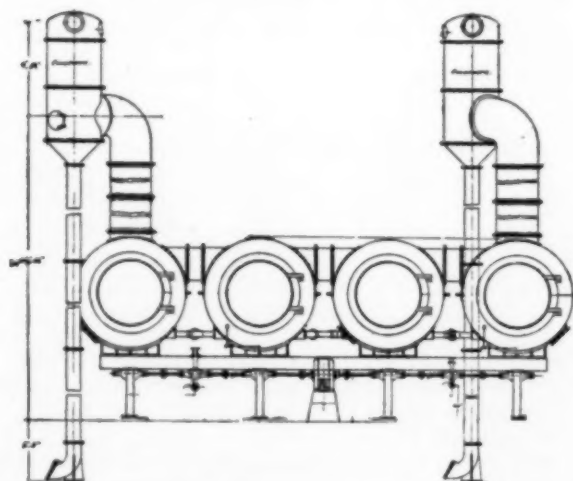


FIG. 24.—MULTIPLE-EFFECT LILLIE EVAPORATOR.

mechanical circulation in longitudinal section. The evaporating tubes incline slightly downward toward the steam end and open through the heavy tube plate partition, in which they are firmly expanded (without annealing) and by which they are supported.

The other ends of the tubes are closed, save for a small air vent, Fig. 23, in each. They are not fastened or supported in any way, and the tubes are quite free to expand or contract independently of the shell of the effect.

On the under side is a specially designed centrifugal circulating pump located midway between the ends of the evaporator and bolted to a well, which, however, is sometimes omitted, in which case the liquor rises sufficiently in the body to float the feed-valve ball float which regulates the feed into the body.

The condensation of the steam inside the tubes flows back into the steam end and thence through a steam trap into the steam end of the next cooler body and finally from the coolest body to the atmosphere, in the case of a multiple effect.

The circulation of the solution over the tubes is a deluging shower, maintained by the centrifugal pump. The circulation is independent of ebullition and there is no depth of solution on the tubes through which vapors must force their escape, as in all submerged-tube evaporators.

The small quantity of liquor in the body is indicated. It is comprised of that in the well beneath the effect plus the liquor flowing over the tubes.

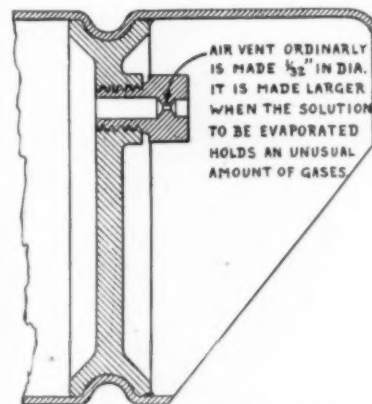


FIG. 23.—AIR VENT OF A LILLIE EVAPORATING TUBE.

The perforated distributing plate above the tubes is formed in sections for convenience in handling. It has one row of holes $\frac{3}{8}$ in. or more in diameter above each vertical row of tubes. There is a 1-in. space between the distributing plate and the tube plate, through which there is a heavy flow of solution upon the surface of the tube plate, which prevents matter caking on the tube plate.

There is also a 1-in. space on each side of the tube plate. The flow of the solution over the side edges of the plates carries with it the particles of scale that may come up with the liquor and prevents them from clogging the perforated plate. These matters pass away when the liquor is discharged from the body and in the case of a multiple effect, finally leaving the apparatus from the last effect.

The feed to the effect is automatically regulated by the feed-float valve to correspond with what passes away from the effect and consequently the liquor level is held practically constant. This is the usual method of arranging the vents for the escape of incondensable gases from the tubes. They are, however, differently arranged to meet different conditions.

These vents should occasionally be tried with a fine wire to see if they are open. A closed vent stops evaporation in its tube.

When combined to form multiple effects (Fig. 24) bodies are placed in line side by side and turned alternately end for end, so that the vapor end of a body is next to the steam end of each adjacent body; this permits short vapor connections between the bodies and the peculiar valve system employed for reversing vapors. The circulating pumps come in line and one shaft is employed common to all the pumps.

In addition to the circulating pumps the shaft usually carries a centrifugal pump for discharging the thick liquor and another for the condensation.

All the latter comes away from the coolest body through this one pump. This shaft is driven by a motor or by a belt from an engine.

The multiple effects are arranged either for not reversing the direction of vapors through the system (the usual manner of working multiple effects) or to permit of reversing the direction of the vapors or heat through the system, which is strictly characteristic of the Lillie multiple effect.

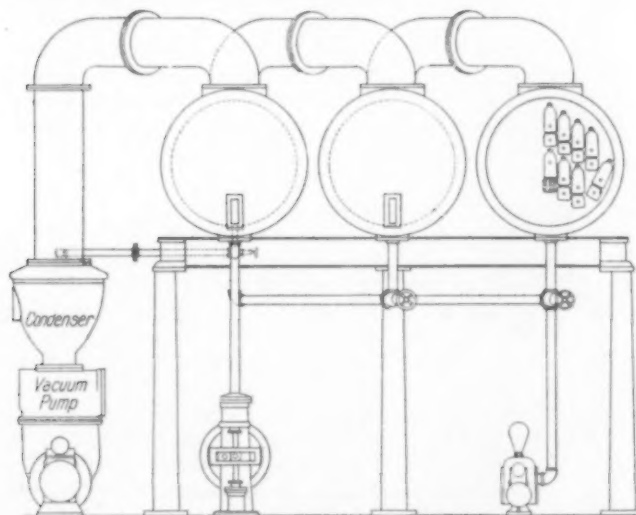


FIG. 25.—LILLIE EVAPORATOR BUILT FOR FUTURE ENLARGEMENT.

Its operation is automatic. The feed of liquor into the first effect and from effect to effect and away from the last effect is automatically regulated by the feed-float valves, no matter what may be the number of effects, with the exception of the regulation of the density of the product by means of the valve in the discharge pipe for the latter. The water of condensation is automatically trapped from effect to effect and all passes away from the coolest effect through the centrifugal condensation pump.

A valuable feature of the Lillie evaporator is its capacity for enlargement, when bodies are constructed with that end in view. It is accomplished by parting the two semi-cylindrical halves of which an effect is composed when constructed for future enlargement and inserting between them a section of tubes carrying the tube surface which it is desired to add (Figs. 25 and 26).

The general arrangement for the reversal of vapors of the Lillie multiple effect or cutting out bodies in times of emergency are simple and almost automatically effected. By re-

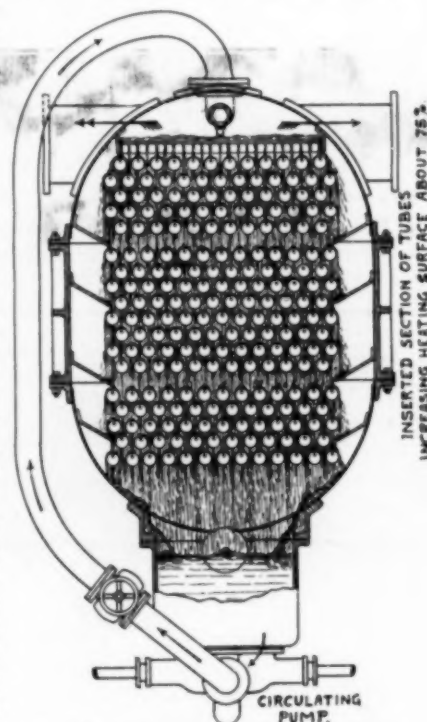


FIG. 26.—ENLARGING LILLIE EVAPORATOR.

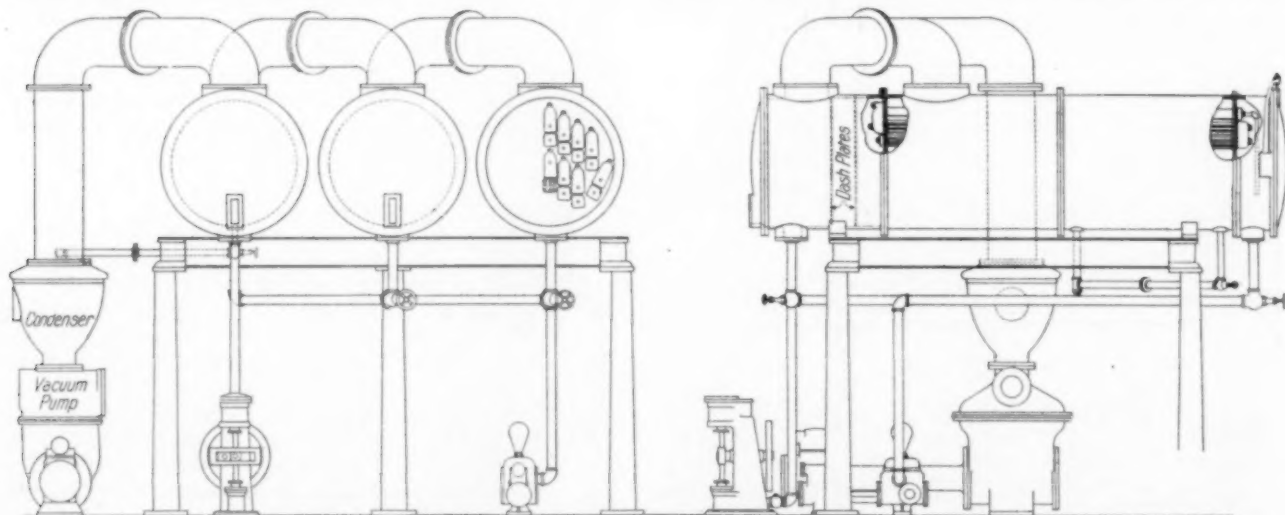


FIG. 27.—YARYAN EVAPORATOR.

The course of the liquor being concentrated is, as a rule, reversible. That is, it may be sent through the effects in succession in either direction, no matter what may be the direction of the vapors through the series. This permits taking the diluted solution into the coolest effect and delivering it concentrated from the hottest effect in cases when it is desirable to do so (when a liquid is to be brought to specially high densities).

versing the direction of the vapors scale does not form on the evaporating tubes, or if it does form it tends to crack and fall off from the tubes on account of the difference in expansion between the scale and the metal of the tubes under the changing temperatures. The time required for reversals is from 5 minutes to 15 minutes each.

Any effect can be cut out of the multiple effect and a quadruple effect can be arranged to run as two double effects.

The efficiency of the heating surface of the Lillie evaporator according to practical experience varies with conditions, but taking hot clarified cane juice and concentrating it to, say, 30 deg. Beaumé, it can be assumed that an evaporation of about 39 lb. per square foot in one body of a multiple effect, working with, say, 5-lb. pressure of steam to the first effect and an

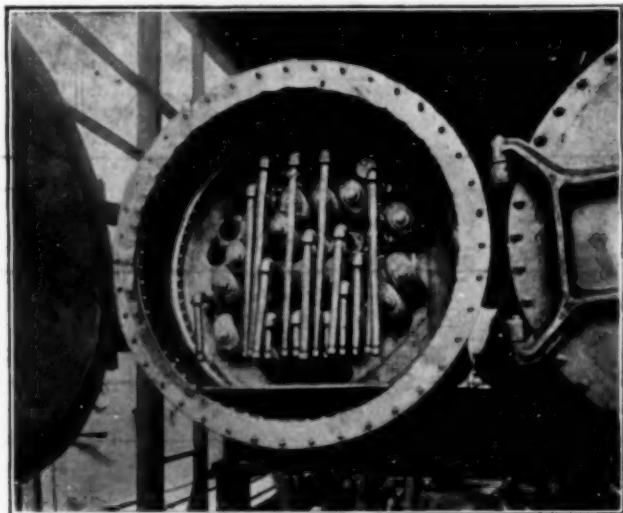


FIG. 28.—YARYAN EVAPORATOR. FEED CHAMBER.

average vacuum in the coolest effect. This would be equivalent to about 10 lb. evaporation per square foot of total heating surface in the quadruple effect and about 13 lb. evaporation per square foot of total heating surface in a triple effect. The Lillie evaporator is used for water distilling and many plants are equipped with it.

The Yaryan Evaporator.

Under this name (Figs. 27 and 28) it is very well known and is now one of the oldest and very much improved evaporator systems with high efficiency. It consists of horizontal, cylindrical bodies with swinging doors at both ends and tubes packed into the tube sheets by return bends and packing glands, which makes it very easy to give the evaporating tubes a thorough cleaning, if necessary. Inside of these doors, as shown in Fig. 28, is a chamber in the front or liquor inlet side, and another chamber at the end or vapor side, where liquors and vapors leave the tubes.

The Yaryan evaporator is a combination of groups of evaporating tubes, each group working for itself. Between the two shells is the steam chamber and the evaporating tubes are there surrounded and heated by the steam.

Since the feed chamber (Fig. 28) for the vertical inlet pipes through which the liquor enters a pipe of larger diameter is surrounded by steam, the liquor begins to boil immediately and rushes with great velocity until it reaches the return bend (Fig. 27) and enters the pipe group with small diameters. By the rapid evaporation in the tubes great quantities of steam are formed which by their expanding force rush the liquid in broken-up streams of films through the pipes.

After these films pass the second return bend in the front they empty their contents with great force against the baffle plates, where the liquid falls to the bottom and continues its way to the next effect or the receiving tank, while the vapors pass over into the steam chamber of the next effect or to the condenser.

The Yaryan evaporator can be used to great advantage for water-distilling purposes as it concentrates any liquid that has a tendency to foam and also, on account of the ease with which the tubes can be removed and cleaned, it can be advantageously used for any liquid that scales the heating surface.

(To be continued.)

New York Meeting of the American Electrochemical Society

The nineteenth general meeting of the American Electrochemical Society, held in New York City on April 6, 7 and 8, was as successful and enjoyable as any that preceded it. For the first time the splendid new Chemists' Building was the gracious host of a national chemical society convention.

The attendance was good, more than 350 members and guests having registered. All the professional sessions, which were held in the spacious Rumford Hall of the Chemists' Building, were well attended. The papers presented were followed with unflagging interest and the discussions were lively and to the point.

No less interest was shown in the excursions which had been arranged for the three afternoons, including two of the largest and best-equipped copper refineries. At the works of the Nichols Copper Company, on Long Island, on Thursday afternoon, the smelting of copper ores and the bessemerizing of copper matte were shown, this being now the largest copper refinery in the world. Of even greater interest was the extended excursion on Saturday afternoon to the Perth Amboy works of the American Smelting & Refining Company, where the processes of electrolytic copper refining and of electrolytic silver refining were also shown, while in the purely metallurgical plant the latest departure of metallurgical practice—the bessemerizing of leady copper mattes in basic-lined converters—attracted naturally the closest attention.

For Friday afternoon a number of optional visits had been arranged, including an excursion to the new works of the Hanson & VanWinkle Company, of Newark, N. J., where the visitors were very cordially received and entertained, and the thoroughly modern and up-to-date demonstrating electroplating plant was shown which is used chiefly for demonstrating the

company's mechanical electroplating apparatus for plating large quantities of work in bulk.

Another party visited the new interesting electric-furnace laboratory of Dr. F. J. Maywald, where both direct current and alternating current is available for experimental work with various types of electric furnaces, and the exceedingly well-equipped plant of the Moss Photo-Engraving Company, where the latest methods of photo-engraving and electrotyping could be watched in commercial practice.

Other parties visited the New York Testing Laboratories, which have already been described in this journal, and the laboratories of Columbia University and of the College of the City of New York.

A subscription dinner "en famille" on Thursday night was very enjoyable. Mr. Maximilian Toch distinguished himself as a most resourceful and witty toastmaster. On this occasion the secretary of the New York Section of the society, Mr. H. B. Coho, presented on behalf of the section a watch fob to Mr. Alois von Isakovics in recognition of his seven years' service as secretary-treasurer of the section and as chairman of the membership committee of the society. The fob was a copy—the first one struck off—of the new enameled gold emblem of the society. Other after-dinner speakers were Professor Walker, Dr. Whitney, Professor Richards, Mr. Sperry, Dr. Baekeland and Professor Bancroft. The dinner, which was a very happy, harmonious and informal affair, was attended by a large number of ladies.

Not less enjoyable, though in a different way, was the smoker on Saturday night. Mr. H. B. Coho, as master of the revels, was simply grand. He was ably assisted by Mr. Frank A. Patison, whose acting was clear-cut art, and by Mr. J. M. Muir,

who managed the affair with great success from the outside. There were songs, presents, speeches, a raid, a newspaper, a love story, and refreshments.

Business Meeting.

The annual business meeting of the society was held on Thursday morning, when the reports of the secretary and treasurer were presented.

In the report of the board of directors, presented by the secretary, Prof. J. W. Richards, it was stated that the increase of the number of members was quite satisfactory, being 145 net during the year. The number of members is now 1294. The financial status of the society during 1910 is also very satisfactory. The excess of receipts above expenditures for the year was \$1,176.40, from which the permanent investment fund was increased by the purchase of another \$1,000 bond.

The result of the annual election of officers was announced as follows: Dr. W. R. Whitney, chief of the research laboratory of the General Electric Company, is the new president of the society. Mr. F. A. J. FitzGerald, Dr. E. F. Smith, and Mr. A. von Isakovics were elected vice-presidents. Dr. E. G. Acheson, Dr. W. D. Bancroft, and Mr. Carl Hering were elected managers. Dr. Joseph W. Richards was re-elected secretary and Mr. Pedro G. Salom treasurer.

Dr. Willis Rodney Whitney, the new president, was born in Jamestown, N. Y., on Aug. 22, 1868. He graduated from the Massachusetts Institute of Technology with the degree of B.S. in 1890 and obtained the degree of Ph.D. at the University of Leipzig in 1896. He was for a time instructor and associate professor of chemistry at the Massachusetts Institute of Technology. In 1904 he accepted the directorship of the research laboratory of the General Electric Company. In this position he has been directing an enormous amount of research work, two brilliant results of which may only be mentioned—the graphitized-carbon filament and the ductile tungsten filament.

Dr. Whitney made a short address, starting with a poem by Browning and ending with a few impressive and characteristic words on universal optimism. Optimism is a wonderful tool in bringing about results. Optimism leads a man to try things. About the carbon ion, if we can get carbon to go as ion into solution, we can make a carbon cell which would revolutionize all methods of generating electrical energy. The ordinary man will say this would be such an enormous result, hence it will probably not work. The optimist goes ahead and tries it. He knows that he has an even chance all the time and he concludes that he had better take the chance.

In the following we give a concise report of all the papers presented at the meeting.

Dry Cell Testing.

Instead of the report of the committee on standard tests for dry cells, which was not yet ready, a paper was presented by Mr. W. B. PRITZ, of the National Carbon Company, of Cleveland, Ohio, on dry-cell testing. The author pointed out the non-uniformity in the tests of dry cells now being employed and emphasized that there is in no sense a relationship between service and short-circuit current. It is true that the amperage reading of a cell, coupled with a familiarity with the particular brand, does serve as a good indication of the age of the cell or the presence of any serious defect; however, the customer who judges solely from the short-circuit current is very apt to obtain very inferior quality, and still dealers state that at least 90 per cent of the customers who buy cells off the shelves demand that they be so read and in most cases select that brand giving the higher current.

The author emphasized the need for informing the customer and for standardizing the methods of carrying on dry-cell tests. In general (other than for purposes of research) there are but two reasons for desiring a test upon dry cells: 1. To ascertain what life may be obtained from a brand of cells in a certain service. 2. To ascertain which one of several brands will give the longest life in that particular service.

With the former object in view the knowledge is best obtained

by actual use of the cells in connection with the appliance. The great majority of tests are carried on, however, with the second object in view, viz., the comparison of two or more brands of cells for use in a particular service. Where the amount of testing is large it is impossible, even where it is expedient, to use the actual appliances for testing cells, and it becomes necessary to devise testing methods and appliances such that results obtained therefrom shall be comparable to the results obtained from the cells when placed in actual service.

It is even questionable whether it is wise to go further and make the operating conditions not only comparable, but as similar as may be to the operating conditions of the service for



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PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY.

which the test is intended since it is not certain that results of greater meaning are obtained from such strict adherence to service conditions.

In general Mr. Pritz advises against test of various brands of cells by connecting them in series and discharging them simultaneously. There are occasions, however, when this is the only method to employ. Especially is this true when test conditions cannot be held constant for the separate testing of various brands. By test conditions are meant length of contact, strength of current and temperature of the battery. It is much preferable, for instance, to use the series method of test upon an automobile than to test the various brands upon different machines or upon the same machine at different times.

Mr. Pritz then discussed the effect of temperature upon dry-cell testing. This effect is three-fold. Firstly, temperature affects the initial current. When cells have been standing in a very cold place they may give such a low amperage as to be unsalable, but when brought to normal temperature the initial current is quite satisfactory.

Secondly, the influence of temperature upon service is greater than is generally supposed. Where comparable results are desired it is of extreme importance that the two batteries be kept at the same temperature. The effect of temperature also varies with the nature of the service, high temperature giving longer service where the drain is heavy, while low temperatures are favorable for light-drain tests lasting over a considerable period.

Thirdly, of prime importance in dry-cell testing is a knowledge of the effect of temperature upon the rate of deterioration of cells when left on open circuit. To determine just what this

effect might be, a number of cells were stored at seven different temperatures. The following table gives the initial currents and the drop in amperage after 10 weeks, expressed as a percentage of the initial values.

Temperature.	Initial Amperes.	Per Cent Drop in Amperes in 10 Weeks.
5 deg. C.	18.1	4.4
25 deg. C.	22.0	10.0
35 deg. C.	21.0	19.0
45 deg. C.	22.8	25.0
55 deg. C.	23.0	52.0
65 deg. C.	20.5	71.0
75 deg. C.	21.0	98.0

The greatly increased rate of deterioration on open circuit at high temperatures no doubt accounts for the poor service obtainable at such temperatures when long periods of time are necessary for its completion. The cells should be stored in a dry, cool place, and not in the corner behind the stove.

The rating of dry cells was next discussed by Mr. Pritz. In regard to the terms in which the results of dry-cell tests should be reported there is some difference of opinion, some authorities contending that the ratings should be expressed as the number of amp-hours given by a cell under specified conditions to a certain working voltage value. Others claim that more practical meaning is attached to a statement of the length of time during which the cell is able to maintain its working voltage above the specified limiting value.

It is the opinion of the author's company that that method of rating should be used which gives to the consumer the exact information which he desires, hence they favor the rating of cells by the length of service of a given kind which they are capable of giving.

The consumer is interested in the length of service which he is able to obtain from a battery and not in the amount of energy given. At first thought it might appear that the amp-hour capacity of a dry cell bears such a relation to length of service that either method of rating would give the same information. Such is not the case, however. Differences in discharge rate cause vast differences in the number of amp-hours obtainable from the cell. For research purposes the watt-hour or amp-hour output of a cell is very useful, but as a practical rating for dry cells it is not satisfactory, especially from the standpoint of the consumer.

Mr. Pritz finally urges the adoption of standard tests and recommends the following two tests for telephone service and gas-engine ignition service respectively:

For telephone service he subjects three cells in series to a discharge through 20 ohms resistance for a period of two minutes each hour, during 24 hours per day and seven days per week, until the working voltage reaches the limiting value of 2.8 volts, the results being reported as the number of hours' service to this cut-off point.

For gas-engine ignition service a battery of six cells is connected in series with a 16-ohm coil, which permits an average drain on the battery throughout its life of approximately 0.5 amp. Readings of the working voltage are taken at intervals throughout the test, the most important reading, however, being the impulse of current which the battery is able to force through a $\frac{1}{2}$ -ohm coil connected in series with the ammeter and in parallel with the 16-ohm resistance. When this value at the end of a period of contact falls below 4 amp the battery is considered unfit for service and discarded. The test batteries are discharged for two hours each day, one hour in the morning and one in the afternoon. As a test for lighter service the battery may be subjected to two drain periods of one-half hour each.

Since it is often the case that quite an interval of time may elapse between the manufacture and installation of a cell in service, a knowledge of what may be expected during this period becomes of no little importance, hence an open-circuit or "shelf-life" test is quite essential.

The method for determining shelf life generally consists of reading the initial voltage and short-circuit current of a representative sample of cells, followed by current readings at intervals of one or two months, depending upon the nature of the cell in question. The ammeter for reading short-circuit current should be dead-beat, and with its leads should have a resistance of 0.01 ohm. Two 30-in. lengths of No. 12 lamp cord make very convenient leads.

The results are merely indicative of internal resistance and bear no definite relation to the service which the cells may give. However, this information, coupled with familiarity with a brand of cells, becomes a very good indication of its quality. It also serves to indicate any serious defects of manufacture.

The cells are kept on the shelf until the short-circuit current

has fallen below 10 amp. This point is arbitrarily chosen, as it represents a point below which it would be difficult to market the cell. For practical purposes the results are expressed as the number of months during which the short-circuit current remains above this cut-off point.

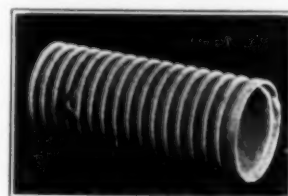


FIG. 1.—ELECTRIC FURNACE CORE OF ALUNDUM.

Much more meaning, however, is attached to the rate at which the current falls, generally reported as the drop in amperage expressed as a percentage of the initial amperage. This is especially true when investigation of the quality of cells is the object. For practical purposes,



FIG. 2.—MUFFLES AND TUBES OF ALUNDUM.

however, the first rating given, i.e., months to 10 amp, is perhaps preferable.

The above paper having been printed in advance was read by title. There was no discussion.

Alundum Refractories.

Mr. L. E. SAUNDERS, of the Norton Company, of Niagara Falls, then presented a paper on electrically fused alumina (alundum) as a refractory. Alundum was primarily developed for abrasive purposes, but its heat-resisting properties were so often urged that it led to its introduction into this field.

There are two forms of alundum of interest in this respect: First, a white crystalline product, having less than 1 per cent of impurities, and, second, a reddish-brown vitreous material having from 6 per cent to 8 per cent of impurities, these consisting in both cases of oxides of iron, titanium and silicon. They are both electric furnace products from the mineral bauxite, having undergone different degrees of purification. The purer white product has a melting point between 2050° C. and 2100° C.; the brown product not more than 50° C. lower. The coefficient of expansion is linear and is, for the white product, 0.000078 and for the brown material 0.000085. The

thermal conductivity is about twice that of Marquart porcelain and three to four times that of most fireclay. The hardness in Mohr's scale is above nine, but lower than ten. The specific gravity in both products varies between 3.93 and 4.00. Both kinds of product are quite unattacked by aqueous acids and alkalis and very superficially by fused alkali carbonates. Basic or acid slags dissolve it with some difficulty, acid slags having a readier action.

Some attempts at molding it from liquid condition have met with partial success, although the difficulties involved are so great that only very simple and crude forms have been made.

The method of application which has been found easiest consists in mingling the crushed grains (the purer form is mostly used) with a binding agent of a refractory and ceramic nature, molding the desired pieces after the manner of the potter and burning them in a ceramic kiln. The resulting articles are more refractory than the binding agents employed, and in nearly every case than amorphous alumina. This is also true of the unbonded product, even in fine powders, and it is a fact for physical chemists to explain. The amount of bond is varied in different forms, but in none of these articles does the melting point drop below 1950° C.

Other properties have changed but slightly. For instance, the temperature coefficient is in the more refractory bonded bodies 0.000059. The thermal conductivity is still twice that of Marquart porcelain. The strength, both tensile and compressive, is very high even at high temperatures. The charge of electrical resistance with temperature as determined by Dr. M. deKay Thompson is as follows: at 535° C., 476×10^8 ohms; at 721° C., 49×10^8 ohms; at 908° C., 24×10^8 ohms; at 1040° C., 7.5×10^8 ohms.

Alundum muffles are distinguished by high thermal conductivity and high melting point. They have four to five times the life of the ordinary clay muffle in gas-furnace work. They are especially adapted to the electrically heated, wire-wound type of laboratory furnace. They have the advantage over quartz of being more refractory and of higher tensile strength. They are porous and cannot be used where entirely gas-tight furnaces are required.

Alundum tubes are similar to the muffles and have found chief use along the same lines. They are also porous and cannot be used for pyrometer protection tubes.

Alundum crucibles are made of varying density, but are still porous in all cases. This prevents their use in fusing slags or salts, but metals, even platinum, may be melted without injury to the crucible. This seeming disadvantage of excessive porosity has been turned to good account in the laboratory sizes. They answer all the purposes of a Gooch filtering crucible without the trouble of preparing the asbestos blanket, and the porosity can be so controlled that the most finely divided substances may be cleanly filtered. The usual analytical precipitates are quickly and surely separated and may be ignited quickly in the crucible on account of its high heat conductivity. Even deflocculated graphite may be separated from its suspending medium.

Large filtering dishes of alundum are also made and have been found useful in making organic preparations and in bacteriological work. An extraction thimble of alundum for the Soxhlet or similar apparatus is very useful as it may be cleaned simply by ignition over a burner and used repeatedly.

Alundum combustion boats of various sizes are valuable on

account of good heat conductivity, mechanical strength and chemical inactivity. If it is desired to use a boat of some other material, some carefully prepared alundum grain free from carbon sprinkled over the bottom prevents the sample from sticking in an oxygen combustion.

A useful modification is alundum cement, which may be used to coat the inside of crucibles and furnaces for high-temperature work. It does not melt or combine with carbon below 1950° C. and may be used for lining larger sized crucibles than it has seemed practicable to make entirely of alundum.

There is a wide field of application, and it is possible to produce almost any shape that may be desired. Indeed the greatest difficulty so far encountered is that each user desires a different shape or size so that it has been impossible to prepare the usual stock.

Mr. Saunders had on exhibition a large collection of alundum articles. Mostly all of the forms shown were of laboratory or semi-commercial types. With respect to the larger commercial uses, Mr. Saunders said that by the very nature of the process of manufacture such a substance is costly and in excuse for the early development of the small articles, rather than more commercial forms, he stated that the cost of the material entering into their composition is relatively small, while in the case of bricks it is relatively great.

Some work has been done, however, on testing out alundum bricks. A Héroult furnace in the experimental department of one Niagara plant was equipped with a roof of these bricks in April last year. Since that time the furnace has been used at intervals totaling about three months' actual running time, with some forty or fifty shutdowns, and the roof is still in usable condition. The temperatures used are decidedly higher than in the steel furnaces, so high, in fact, that a regulation silica roof previously tried went down in five or six hours. A trial is now under way in the Héroult furnace of the Halcomb Steel Company, and so far the roof has been in use for twice the life of a silica brick one and is still in fine condition. Until this and other trials are complete no claims will be made for alundum brick. They cannot economically be used, however, in contact with slags, either acid or basic. Nor can they be usefully employed where the present refractory life is very long.

The paper of Mr. Saunders was discussed at some length by Messrs. Tucker, Lidbury, Hering, Hansen, Beckman, Amberg, Richards and Queneau. In reply to questions Mr. Saunders stated that he had determined the comparative melting points of seven commercial refractory bricks; they are in the order of their melting points from lower to higher temperatures as follows: silica brick, chrome brick, bauxite brick, brown magnesite A, brown magnesite B, Grecian magnesite, alundum.

As to the attack of alundum articles by ordinary laboratory reagents, Mr. Saunders stated that first treatment with H_2SO_4 and HCl takes off a little in weight from the alundum article, but never more than three hundredths of a per cent; later treatment takes away nothing. For this reason a preliminary wash of the alundum article is recommended.

As for certain purposes it is important to know the softening temperature rather than the melting point, Mr. Saunders stated that solid alundum does not soften within 100° of its melting point. Bonded articles hold together at 1950°, but would change their form under pressure at that temperature.

With respect to the use of alundum brick for roof construction of electric furnaces, Mr. Hansen pointed out the disadvantage of silica roofs in that they are liable to spoil the bath. The silica roof absorbs basic fumes which reduce the melting point. Alundum is not thus affected, and alumina dripping into the furnace from the roof would not have the same disastrous effect as silica dripping into it.

Dr. Richards pointed out that the high thermal conductivity of alundum would make it an excellent material for zinc re-
torts. To prevent heat loss through the alundum roof of electric furnaces the roof would be jacketed.



FIG. 3.—ALUNDUM FILTER.

New Resistance Furnace.

An account of a new resistance furnace, designed originally by Mr. John Thomson and Mr. Francis A. J. Fitzgerald for carrying out the Imbert electric zinc smelting process, was the subject of a paper of Mr. F. A. J. FITZGERALD, of the Fitzgerald & Bennie Laboratories, Niagara Falls, N. Y. This fur-

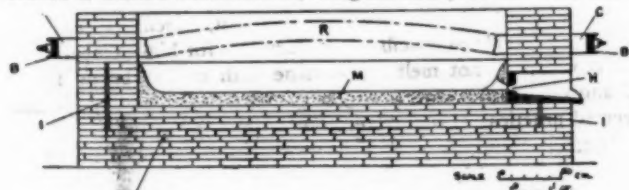
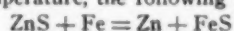


FIG. 1.—LONGITUDINAL SECTION OF RESISTOR RADIATION FURNACE.

nace has already been noted in our Vol. VIII, pages 289 and 317 (1910).

If zinc sulphide and metallic iron are heated together to a sufficiently high temperature, the following reaction occurs:



It appears, however, that this reaction is incomplete unless there is a large excess of iron present, or unless the temperature of the reaction is very high. Imbert discovered¹ that by using suitable "dissolvents" this objection to the process is overcome. For example, he found that ferric oxide and iron sulphide mixed together in the proportion of one part and three parts respectively formed a very fluid bath at a temperature between 1000° and 1100° C., and that this bath would "dissolve" six parts of blende. Now, when the zinc blende is "dissolved" in a bath in this way and treated with iron, the reaction given above is complete and works very easily, the zinc being given off as vapor and a residue obtained, which consists of two parts: a slag formed of the gangue of the ore and iron sulphide, which may be used for the regeneration of iron, etc.

The experiments made by Imbert were satisfactory, but the

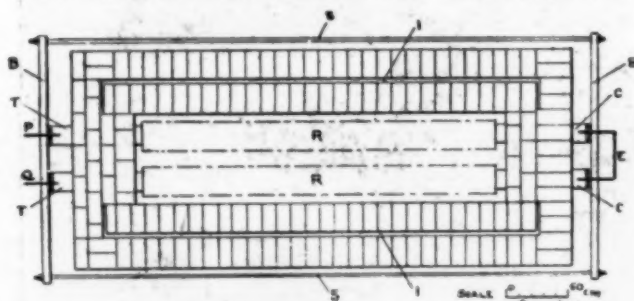


FIG. 3.—PLAN OF COVER OF FURNACE.

process is obviously not suitable for the ordinary zinc retort, and it was thought that an electric furnace might be used with economy. Experiments with various electric furnaces were tried, and finally the kind which forms the subject of this paper was devised.

The conditions to be met by the furnace are as follows: It is desired to obtain a bath of molten iron, to which can be added a mixture of the zinc ore and the "dissolvent." The furnace must be gas-tight and must be constructed with sufficient ruggedness to withstand high temperatures and rough usage over prolonged periods. It must also be so designed that the temperature can be readily controlled, and finally the heat losses must be reduced to a minimum.

The first furnace constructed had an oblong reaction chamber, which was roofed over by the resistor. This was built of carbon rods laid transversely across the top of the reaction chamber, the ends of the bottom row of rods resting on ledges built of magnesite brick. The resistor was in contact with the furnace terminals, which were situated at either end. A charg-

ing door was provided under one terminal, while the tap-hole was under the other. The melting chamber of this furnace had a capacity of 250 kilograms (550 pounds) of iron.

Several experiments were made, but the most important was one lasting 3 days, 5 hours. During this experiment a quantity of pig iron was melted in the furnace, and it was found that with a temperature in the bath of 1300° C. the radiation loss was about 18 kilowatts. Since the full working capacity of the furnace was 40 kilowatts, the efficiency at 1300° C. was 55 per cent, which is not bad considering the small size of the furnace. This experiment was ended by keeping the current at 40 kilowatts without charging anything, the object being to

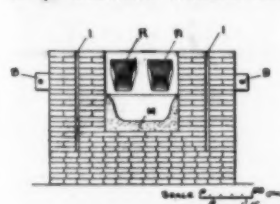


FIG. 2.—CROSS-SECTION OF FURNACE.

find out how the furnace would finally fail under the increasing temperature. As was expected, failure occurred through the fusion of the magnesite bricks which supported the rods of the resistor.

After the furnace had cooled it was taken down and examined, with the result that an interesting observation was made which gave a good notion of the temperature finally obtained in the bath. The reaction chamber was lined with Dixon's graphite-clay mixture, used in making crucibles, and it was found that this had been largely converted into amorphous silicon carbide.

Various critics of a furnace built according to this plan have pointed out that an unsatisfactory feature is the risk of fusing

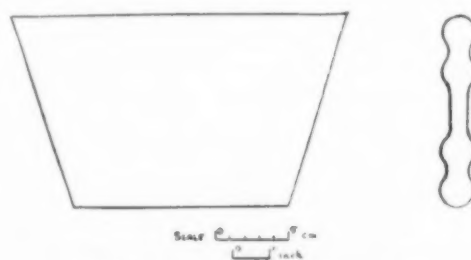


FIG. 4.—RESISTOR CONSTRUCTION.

the cover. Presumably the heat radiated from the top of the resistor, which, of course, is just underneath the roof, would be so great as to be very severe on that part of the furnace. This objection, however, is not serious, for the current density at the lower part of the resistor is greater than at the top. The carbon rods forming the lower part of the resistor are in much closer contact than those in the upper part, on account of the weight of the upper carbon rods, consequently the resistance of the lower layers of carbon rods is less than that of the upper layers. The fact that the magnesite bricks below the resistor were fused at the end of the experiment, while the roof, which was built of a good grade of ordinary fire brick, was unharmed, shows clearly the difference in temperature between the upper and lower parts of the resistor. Moreover, by means of pyrometers actual determinations were made simultaneously of the temperatures in the bath and in the space between the top of the resistor and the roof. These showed that when the bath had a temperature of 1500° C. the temperature in the space above the resistor was only 1250° C.

In view of the fact that the final failure of the furnace was due to the excessively high temperature reached at the end of the experiment, it was concluded that for the lower temperatures required in working the zinc process, no difficulty of this kind would be encountered. Accordingly, a furnace having an estimated capacity of 150 kw was designed. In order to obtain a sufficiently high resistance in the resistor it would have been necessary to give this furnace a length considerably greater than its width, which would be objectionable on account of the relatively large radiating surface that would result.

¹U. S. Patent, 875,579; Dec. 31, 1907.

Consequently, the furnace was constructed with both terminals at one end and the resistor in two sections connected with each other at the end of the furnace opposite the terminals by a graphite connector. One side of each section of the resistor was then supported on a ledge running along the side of the furnace, while the other sides were supported on a series of arches spanning the center of the reaction chamber in a longitudinal sense. By this arrangement a nearly cubical form was given to the furnace, and consequently the radiating sur-

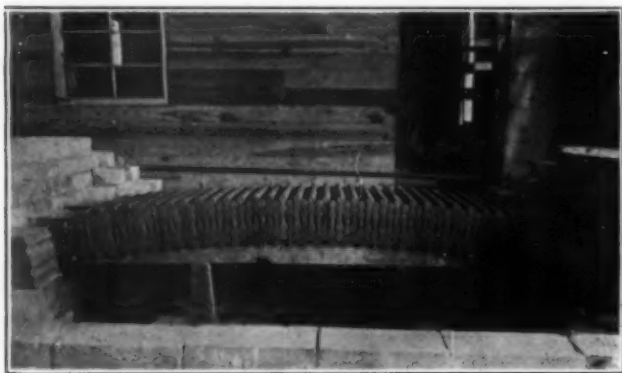


FIG. 5.—RESISTOR PLATES ASSEMBLED.

face reduced to a minimum. The inside dimensions of the reaction chamber were approximately 1400 mm (55 inches) square and 250 mm (10 inches) deep. The resistor was built of rods 19 mm ($\frac{3}{4}$ inch) in diameter and 500 mm (20 inches) long. There were seven layers of these carbon rods in the resistor, each section of which was approximately 1140 mm (45 inches) long.

The experimental work on the zinc process was carried out at the plant of the Hohenlohe Works A. G., Hohenlohehütte, Upper Silesia, where the electrical apparatus was installed and the furnace constructed under Mr. FitzGerald's supervision. The electric current was supplied to the plant at 6000 volts, and was transformed by a special transformer. The construction of the plant and the carrying out of a long series of experiments occupied over three months, and the results obtained with the furnace were satisfactory. The highest temperature actually measured in the furnace was 1460° C., but higher temperatures were certainly obtained.

Very interesting experiments were made on the heat losses of the furnace. During one part of the experiments the furnace was held at a constant temperature of 1250° C. to 1260° C. for over three days. During this time the furnace contained a bath of pig iron, and was absolutely idle, so that the energy generated was used simply for supplying the heat lost by conduction and radiation. The rate of generation of energy, when an absolutely constant temperature both in the bath and walls of the furnace was reached, was 33 kw. If, therefore, the furnace is working at 150 kw and a temperature of 1250°, the heat losses would be 22 per cent.

Another experiment was made which lasted 12 hours, and during this time the temperature of the bath was maintained at about 1450° C. Unfortunately, the temperature of the furnace as a whole was not constant at this time, for the temperature of the walls increased 100° during the experiment. The rate of generation of energy during this period was 42 kw, which, working at 150 kw, would give a loss of 28 per cent.

It must be noted that the heat insulation of this furnace was not by any means as perfect as it could be made. The thickness of the walls in the upper part of the reaction chamber was only 340 mm (13½ inches). That a much more efficient use of the heat generated could be made by more careful attention to heat insulation was demonstrated by later experiments.

The chief weakness shown by the furnace was in the magnesite bricks which formed the supports for the ends of the resistor carbons. The temperature of the resistor is very high, as was shown by making determinations of the density of the carbons forming the resistor after they had been in use. This shows that temperatures at least as high as 1900° C. were reached in the resistor itself.

In the experiments made with the Imbert process it was shown that the most satisfactory temperature for carrying on the reaction was between 1350° C. and 1400° C. in the bath, which would not require these excessive temperatures in the resistor. Nevertheless, it was seen that the work had to be carried on too close to the limitations of the refractories, and this led to the development of a furnace of a different model.

In working the Imbert process the furnace is filled simply with vapor of metallic zinc, consequently there is no danger of burning the resistor carbons. The charging devices are so arranged that air is not introduced into the furnace, so that the



FIG. 6.—TOP OF FURNACE.

zinc vapor does not burn to zinc oxide which would, of course, attack the carbon of the resistor. If, however, the furnace is used for other purposes it might be necessary to protect the resistor from combustion. For example, if a furnace is desired for copper melting it would be inconvenient and complicated to make arrangements absolutely to exclude air. It is better to enclose the resistor in a chamber, the bottom of which forms the roof of the melting chamber, and then make this resistor compartment air-tight.

A great many experiments were made to determine the best material for forming this combined floor and roof, which requires above all two qualities: refractoriness and high heat conductivity. The result was the choice of recrystallized silicon carbide tiles. These are found to be satisfactory and to last well, even under severe usage. It would obviously be difficult to construct the resistor chamber so that it would be perfectly air-tight, so to prevent all possibility of oxidation it is desirable

to introduce an inert or reducing gas into the resistor chamber and to maintain this atmosphere slightly above external pressure.

A simple method, employed with success in experimental furnaces, is to put a long pipe in the cover of the furnace and mount on this a large oil cup with a sight feed. The oil cup is filled with kerosene, which is allowed to drop slowly into the resistor chamber so as to keep the latter continually full of oil gas. In one furnace constructed in this way after two months' continuous running the current was cut off, the furnace allowed to cool down and the resistor chamber opened. The resistor was found to be in excellent condition, though a few repairs to the terminals were necessary. The resistor chamber was then closed and the furnace is still running in a satisfactory manner, so that altogether the furnace has been working, with slight repairs, more than four months. This particular furnace had been used for a great number of experiments at temperatures varying from 1000° to 1500° C. (1830 to 2730° F.).

In a furnace constructed with the separate resistance chamber several experiments were made on melting aluminum, copper, monel metal, and iron, but the value of these was qualitative rather than quantitative. The furnace walls were only 230 mm (9 inches) thick, consequently the heat losses were so great that the furnace was not by any means efficient. The object of the experiments was to study the weak parts of the furnace. They confirmed what had been already observed, viz., the weakest part of the furnace was the support of the resistor.

The new model of the furnace is illustrated in Figs. 1 to 5. Fig. 1 is a longitudinal section of the furnace, the cover not being shown. Fig. 2 is a transverse section, and Fig. 3 a plan with the cover removed.

The walls and bottom of the furnace are cellular as well as the cover, so that it is almost completely surrounded with an air jacket as shown at I in the Figs. T,T, C,C, are carbon plugs which pass through stuffing boxes in the end walls of the furnace, T,T are the terminals of the furnace and are connected to the cables indicated by P and Q.

C,C are simply connected electrodes which form the other terminals of the sections of the resistor R,R and are connected by E. Bearing on the terminals T,T and the connector electrodes C,C are the channels B,B, which are connected to each other by the tension rods S,S and are insulated from the carbons. The lining of the furnace is shown at M and the tap-hole at H.

The resistor R,R is constructed of corrugated plates (Fig. 4), where the section is shown on the left and the form in which the plates are cut on the right. In Fig. 5 is a photograph of the plates set up to form the resistor. Referring to Fig. 4 it should be noted that the thickness of the corrugated plate is not the same at the top as at the bottom, but increases from the bottom up, so that when put in place they form an arch as shown in Fig. 5.

This arch form is not necessary, since the interlocking of the corrugated plates holds up the resistor perfectly well without any arch, but it seems to be desirable in the preliminary assemblage and also permits us to obtain a greater current density on the lower surface of the resistor.

By constructing the resistor in this manner all contact with refractories is avoided, the support being furnished by the carbon terminals. The form of the plates is not, however, solely designed to provide an interlocking device, but also to give a high contact resistance.

In one of these furnaces which was built for zinc smelting at Hohenlohehütte, O. S., there were 71 of these plates in each section of the resistor. The dimensions of the plates were as follows:

Length at top.....	405 mm (16 inches)
Length at bottom.....	255 " (10 ")
Width	165 " (6.5 ")

When cold the resistor had a resistance of 0.200 ohm and

when running at the full capacity of 150 kilowatts and with a temperature in the furnace of 1400° C. the resistance was 0.075 ohm. Now, if the resistance of the carbon itself is calculated it is found to be only 0.00064 ohm, consequently 98 per cent. of the total resistance is due to the contacts between plates.

In order to run a furnace of this kind it is necessary to have means by which a variable voltage can be applied to the terminals of the furnace. If the current is supplied at high voltage and has to be transformed there can be no doubt that the most satisfactory electrical apparatus is something in the nature of an induction regulator which permits of a continuous variation of voltage over a considerable range; but satisfactory results may also be obtained with a transformer from which several taps are brought out from the primary coil, so that the secondary voltage can be changed in a series of steps.

Both for the furnaces built at Hohenlohehütte and those in the FitzGerald and Bennie Laboratories transformers built by the Pittsburg Transformer Company are used with great success. These transformers have a capacity of 150 kilowatts and have 22 taps brought out from the primary coil. Leads are brought out from the two secondary coils and go to a switch so arranged that the coils may be connected either in series or parallel. When all the turns of the primary coils are in circuit the e.m.f. at the terminals of the secondary coils is 50 volts. Then as the turns are cut out of the primary coils the e.m.f. at the terminals of the secondaries is increased in steps of 2.5 volts until a maximum e.m.f. of 100 volts is obtained. By this arrangement there are obtained at the terminals of the furnace voltages of 50 to 100 in 2.5-volt steps and 100 to 200 in 5-volt steps.

When the furnace described above is to be used with an oxidizing atmosphere in the melting chamber the resistor is in a closed compartment, the floor of which is made of recrystallized carborundum plates or graphite plates coated with recrystallized carborundum to prevent them from burning. Fig. 6 is a photograph looking down into one of these furnaces and shows the two terminals and a few of the plates which form the bottom of the resistor chamber in place. The photograph also shows one section of the resistor mounted in clamps and ready to be put into the furnace.

Some anxiety was felt in regard to this design for a rather obvious criticism was that there would be a considerable loss of heat in passing from the resistor chamber to the melting chamber. In other words the thermal conductance of the side walls and top of the resistor chamber would approach that of the bottom of the resistor chamber in spite of the high conductivity of the latter.

Fortunately these fears proved to be groundless, for in the case of the furnace shown in Fig. 6 it was found that with a temperature of 1160° in the resistor chamber there was a temperature of 1090° in the melting chamber, and with a temperature of 1400° in the resistor chamber a temperature of 1290° in the melting chamber. In this particular furnace the heat insulation of the side walls and top of the furnace was not good, owing apparently to the high conductivity of the refractories employed, so the thermal conductance was higher than it should be.

Mr. FitzGerald believes that this furnace will find various useful applications. It apparently gives excellent results in the melting of copper, brass, aluminium, etc. It has not yet been tried for glass melting, but it is thought it will do this work well. Finally Mr. FitzGerald pointed out that the design of this furnace is such that it lends itself readily to the combination of fuel and electric heating. Preliminary experiments in this direction have been carried on and the results are highly satisfactory.

Mr. FitzGerald's paper was discussed by Dr. Whitney and Mr. Carrier. The latter asked as to the advantages of a resistor heater as a radiator over an arc. Mr. FitzGerald replied that with an arc the temperature is definitely fixed to a certain

extent and is higher than is necessary in many cases; further, there are electrode consumption and electrode troubles.

Replaceable Unit System of Electric Heating.

Mr. MILTON M. KOHN, of the Multiple Unit Electric Company, of New York, presented a paper with demonstrations on a new replaceable unit system of electric heating. The essential features of this system have already been described on page 229 of our April issue. In this abstract, therefore, only such new points as were brought out in Mr. Kohn's paper are given.

Mr. Kohn pointed out that in comparison with the use of electricity for lighting and power purposes the amount of electric power employed for heating is practically negligible, although electric heating has the advantages of cleanliness, ease of handling, adjustability, and high efficiency. Mr. Kohn finds there are two reasons for this, first the comparatively high cost of electric current, and second the certainty of the electric heating device burning out sooner or later, no matter how carefully it may be used. This latter disadvantage is practically overcome in Mr. Kohn's replaceable unit system, as any heating unit which may burn out can be quickly replaced, as described in our April issue.

Some essential features of his system are summed up as follows: In the first place there is no special chamber used, nor is there one required, except for extremely fine and delicate work, the units themselves forming the chamber. In the second place the resistor is placed in units which have open slots towards the inside of the furnace, so that while the resistor is protected from mechanical and electrical injury which might result from the work which is placed in the furnace, it is still in such a position as to give off its maximum heat to the work, thereby giving greatly increased efficiency.

In certain industrial work, such as burning color on china, glass and similar material, there are pieces, such as very thin plates, plaques and other fragile shapes, where the heating should not be uniform because of differences in cross-section. In other words the same heat applied to the very thin almost knife edges of such work will almost certainly burn or melt the color off it, whereas that portion which is the thickest can safely stand a higher temperature. By the unit system of construction it is a very easy matter to so control the temperature on that portion of the furnace that the narrow or thin edges of the work can be heated very much slower or at a lower temperature, if desired, than the thick or body portion.

Again, in the laboratory work for the heating of various liquids, gases, etc., it is sometimes desirable to have the heating only on one side of the receptacle, which may be a tube, flask or other differently shaped device, for the purpose of watching the work while it is being heated. To this end Mr. Kohn employs either a standard unit or a special one built for the particular work in question, which can furnish just the proper degree of heat and at the exact spot where it is wanted.

Another example is afforded by cases where it is desirable to have a "progressive heat." That is to say, that the heat should start very gradually at one end, and increase by successive stages up to the maximum. This can also very easily be done by using a unit of the required shape and length and so placing the convolutions of the heating medium that the heat will be progressive or gradual as required.

Again, by the unit system of construction the heat can be made absolutely uniform throughout the entire structure, or by various methods of connecting the units with and without resistance, which latter can be a part of the unit, a separate resistance in the furnace proper, or an external resistance, or a combination of all three of them together, the heat control can be made as gradual as may be required for the most delicate work.

As to the flexibility of construction, Mr. Kohn gave the instance of a muffle furnace in which the housing or body consists of a number of sections of refractory material; these are

formed to make the desired shape, four of them generally being in a layer and possibly three layers being required to make a standard length of furnace. If it is desired to increase the length of the furnace all that is necessary is to increase the number of layers so that there is no limit to the length, except that caused by mechanical strength. The units which fit into this furnace are made in the same way; additional lengths can be added so as to make the required length.

In order to increase the cross-section of a furnace of this character all that is necessary is to insert between the corner pieces which make up the housing or support for the units a distance piece of the required dimensions by means of which the cross-section can be indefinitely increased, the limitation being mechanical. The units are increased in the same manner by inserting a special shaped distance piece, which has the same cross-section as the unit with which it is to be used.

The system is also well adapted to making special heating devices to conform to any specially shaped article that it is desired to heat. For laboratory work hot plates for sand baths, etc., can be made of any size or shape, and to give any desired temperature and any heat control by a simple combination of standard sizes of units and different combinations of circuits. For domestic use this type of construction has an unlimited field.

Another feature of value for domestic and laboratory use is that by means of units which are wound for the various standard voltages it is not necessary to have separate complete devices, but only an extra set of units, so that where a device has been purchased to operate on a 110-volt circuit the purchase of an extra set of units wound for a 220-volt circuit will enable the same device to be used on the higher voltage, everything else remaining the same as before.

Mr. Kohn exhibited some standard types of his furnace and purposely burnt out some units in one of the furnaces in operation in order to show how quickly the burnt-out heating units can be replaced and the furnace restarted.

In the discussion Dr. J. W. Richards criticised the black outside of the furnace and stated that if it was painted white with aluminium paint it would result in a saving of 10 per cent of the heat to keep up the same temperature. Dr. Patten described some experiments of his own with replaceable heating resistor units.

Electric Furnace for Heating Bars and Billets.

Mr. THADDEUS F. BAILEY, of the Bailey Engineering Company, Alliance, Ohio, presented a paper on his new electric furnace for heating bars and billets. This method had suggested itself to him when noting the very wasteful and thermally inefficient oil-fired furnaces for heating forging stock used in a comparatively modern plant in northern Ohio.

A calculation of the thermal efficiency of the furnaces in question, which were said to be of the most modern construction, showed that less than 4 per cent of the heat value of the fuel was delivered into the steel.

Mr. Bailey's electric furnace, which is shown in Figs. 1, 2, 3, is of the resistance type, and consists essentially of two carbon electrodes, spaced from each other, and an intermediate resistance body of a carbonaceous composition in which the heat is generated. In the space directly above the resistance material and directly under the roof of the furnace is placed the metal to be heated, a ledge at the rear of the furnace and one at the opening supporting the bars or billets, as the case may be.

The electrodes enter the furnace through the rear wall, and are placed slightly convergent, so that the path of the electric current will be shorter from electrode to electrode at the front of the furnace than at the back. This arrangement compensates for the cooling effect, which is greater at the front of the furnace on account of the opening and the charging of the cold material.

The electrodes entering the furnace from the rear present

comparatively large contact surfaces to the resistance material, without the use of special electrode sections. The electrodes are also placed in a plane above the resistance material, which throws the shortest path for the electric current in the upper part of the resistance body and nearest the metal.

This is a feature that seems almost indispensable to the successful operation of a furnace of this character, since in the furnaces constructed without this feature the cooling of the upper

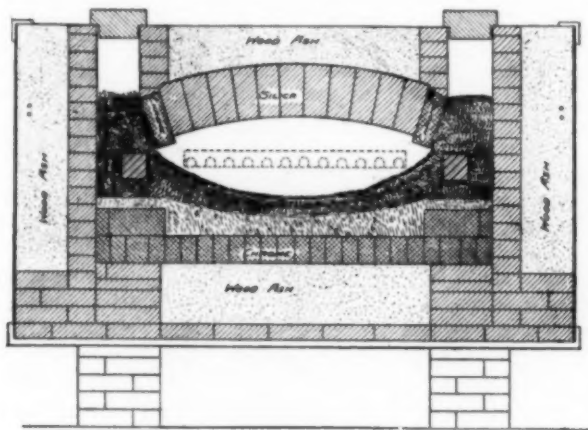


FIG. 1. VERTICAL, RIGHT-LEFT SECTION

part of the resistance body by the cold steel caused the electric current to take a lower path, in which portion of the body the temperature became very high and melted out the bottom linings and the bottom of the furnace itself, and at the same time did not maintain the heating chamber at a temperature high enough to heat the metal.

The resistance material is composed of coke or coal. Crushed foundry coke passing over a 0.25-in. (6-mm) ring and through a 0.37-in. (9-mm) ring giving the most satisfactory and uniform results. For a 40-kw furnace, heating 150 lb. (69 kg) of metal per hour, the distance between electrodes should be 36 in. (90 cm) and the cross-sectional area about 24 sq. in. (150 sq. cm). To maintain an electrical input of 40 kw a voltage of 200 would be required with a coke resistance body; if the body is composed of coal, the voltage should be about 150 volts.

It is extremely difficult to determine the effective cross-sectional area of the material through which the electric current passes, as at working temperatures the lining materials become almost as good conductors of electricity as the resistance material itself.

The resistance body as it approaches the electrodes has a very greatly increased cross-section, so as to provide a better contact with the electrodes, prevent undue heating at the point of contact, and prevent, to as great an extent as possible, the dissipation of heat through resistance to the passage of the current except at that part of the resistance body directly under the metal.

The most serviceable lining material used by Mr. Bailey is made of chrome brick and chrome ore. The top of the furnace is composed of silica arch brick, and is 9 in. thick,

and clamped from front to back. A row of chrome arch brick is placed at each side of the roof to prevent contact of the silica brick with the carbon in the hoppers above the electrodes.

The sides of the furnace are composed of silica brick and, in the larger furnaces, are incased in a sheet steel frame. Insulating material is placed between the silica brick and the casing.

The furnace base consists of a heavy cast-iron plate supported by cast-iron legs or brick piers.

The cable terminals are connected with the electrodes by means of iron sleeves, copper straps and iron wedges.

In making the connection the iron sleeve is placed over the end of the electrode and copper straps placed against the four sides of the electrode. The copper cable terminal is then placed between one of the copper straps and the iron sleeve, and wedges driven in on the opposite side between the strap and sleeve, and a firm contact thus secured. Wedges are then driven in on the other two sides between the copper strips and

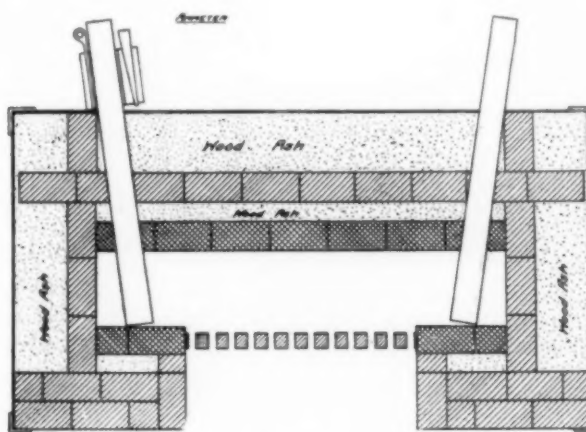


FIG. 3. HORIZONTAL SECTION.

the sleeve. In this way the current flow is equally distributed on all four sides of the electrode by means of the encircling iron sleeve.

The furnace is controlled by means of the regulating transformer and controller. The transformer gives full rated output at the lowest voltage rating. While hand regulation is usually provided the regulation may be made automatic at a slight additional cost. A voltage range of from 33 to 50 per cent is usually provided, depending on the operating and starting requirements.

The metal being heated is maintained in a reducing atmosphere, the high temperature carbon resistance material giving off a gas of a reducing nature. The electric furnace is the only furnace built in small units in which both a high temperature and a reducing atmosphere may be maintained. The saving in oxidation loss is very considerable in small furnaces of this character, as the loss from oxidation in the usual combustion furnace is the cause of the loss of a large number of forgings, due to the fact that a piece of stock, having lost a considerable amount of metal by the oxidizing flame of the combustion furnace, does not contain enough metal to fill the dies.

The thermal efficiency of the furnaces varies with the size, the percentage of operation at full capacity and the ruling temperature required. Efficiencies of from 33 to 65 per cent may be expected in furnaces with heating capacities of from 120 lb. (55 kg) per hour to 1000 lb. (455 kg) per hour.

In the concluding part of his paper Mr. Bailey gave details of a test of an experimental furnace at the plant of the Transue & Williams Company in Alliance, Ohio.

The principal advantages of this electric furnace are stated to be its high thermal efficiency, its non-oxidizing atmosphere in the furnace chamber at all temperatures, and its freedom from

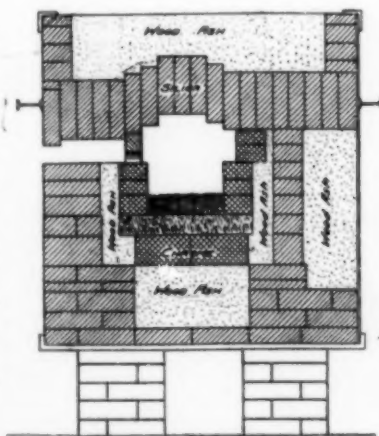


FIG. 2. VERTICAL FRONT-BACK;
MIDDLE SECTION.

soot, smoke and the hot contaminating gases of the products of combustion.

In the discussion of Mr. Bailey's paper Dr. Richards remarked that the efficiency of this furnace was high in view of the unfavorable conditions and that very effective use was made in this furnace as in Mr. FitzGerald's furnace (see abstract above) of the principle of getting the resistor hottest at the place of its radiating surface. Messrs. Hering, Sperry, Lidbury and Hitchcock also participated in the discussion.

As to the "efficiency" of an electric furnace, Dr. Richards proposed to define it as the ratio of the heat actually used for

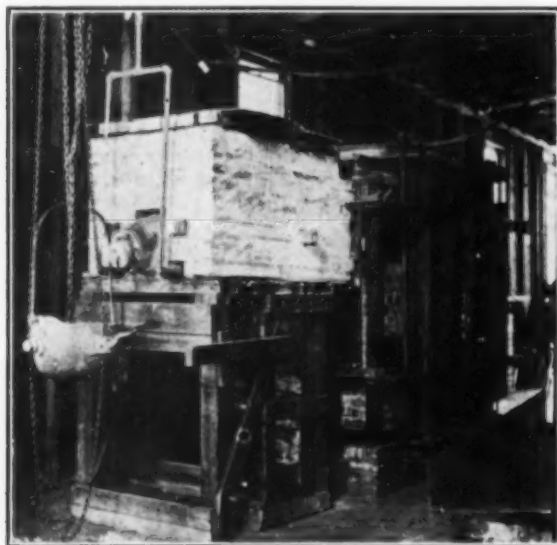


FIG. 1. ELECTRIC ZINC FURNACE.

useful purpose to the electric energy consumption. Mr. Lidbury did not like this definition, as according to it any furnace in which the temperature of the charge is not raised, for instance the Heroult steel furnace, would have zero efficiency.

In reply to a question of Mr. Hitchcock, Mr. Bailey stated that coke was usually added every five or six hours.

Electric Zinc Furnace.

Prof. Jos. W. RICHARDS, of Lehigh University, then presented a paper on the Johnson electric zinc furnace. He stated that at the present time there is considerable interest among metallurgists in electric zinc smelting. This is an exceedingly gratifying circumstance to the American electrochemical world, as thirty years ago those electric furnace pioneers, the Cowles Brothers, tested out an electric furnace for smelting zinc ores from a New Mexican zinc-copper mine. As zinc smelters they were ahead of their time, but their interest in that zinc mine was one of the predisposing causes of the rise of the electro-thermic industries during the last two decades of the last century.

If the zinc business once helped the electric furnace, certainly now the electric furnace can help the zinc business and repay its debt by giving it a continuous furnace of large capacity. For it is a commonplace remark in metallurgical circles that the process for making spelter has not been improved in principle since its birth, one hundred or more years ago. This is true in a measure and in a measure untrue. It is untrue in that hydraulic-pressed retorts and regenerative retort furnaces and mechanically operated calcining furnaces are advances. But it is true in that the same old retort averaging a charge of 50 lb. (23 kg) of roasted ore, with the costly and inefficient crude hand labor, with its limited life and its inability to stand corrosive ores, is still the operative unit. In the United States there are some 100,000 retorts making each 5000 lb. of metal per year.

Now, in this respect the electric zinc furnace which puts the heat right where it is needed and used, and so can be built in large sizes, is far ahead of the old retort potentially. Furthermore, a continuous character of operation is possible in electric smelting, and this is inherently better than the intermittent character of the present method of smelting of zinc ores.

It is quite within the bounds of probability to expect 500-kw zinc furnaces, each making 4000 tons of metal a year, the equivalent in production capacity of 1600 retorts.

The natural presumption is that when once developed to a practical and commercial basis the extraction of the main and by-product values will be greater in the twentieth century process than in the nineteenth century process. Likewise the labor charge per ton of ore will be far less, the metal purer and more uniform. The capacity for smelting a variety of ores will be greater, and the control of temperatures be better. The cost of electric power will approximately equal the cost of coal in the present practice.

Mr. W. McA. Johnson's first large-scale experimental work in the electrometallurgy of zinc was directed along lines of treating a charge that produced a dry fusible residue. Much actual progress was made in that line. Photographs of his earlier furnaces are shown in Figs. 1 and 2. He later concentrated his investigation on a proper practical condenser for large-scale continuous operation, which he considers to be the keystone of the "electric zinc" problem. For the last two years Mr. Johnson has been engaged in developing an electric fur-

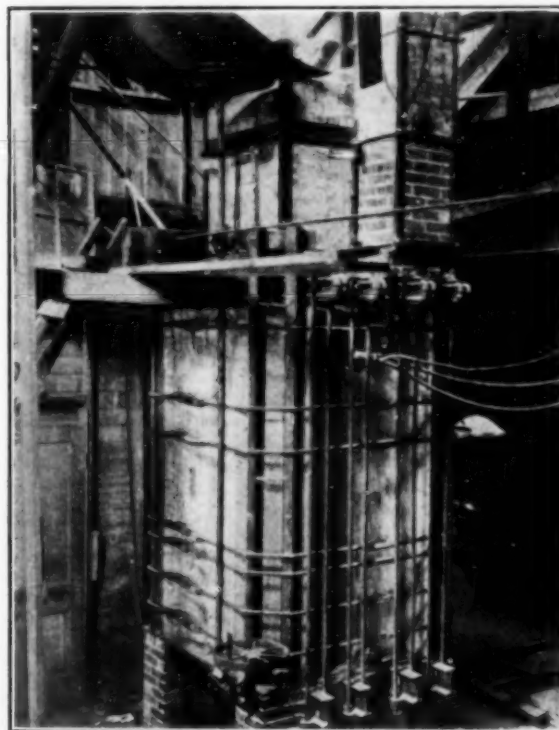


FIG. 2. ELECTRIC ZINC FURNACE.

nace to smelt zinc ores with the production of a base lead bullion, a copper-matte and a fusible slag. This is more difficult than the dry process, but far more attractive commercially. To use his own words "the smelting zone of my electric zinc furnace is practically a lead furnace, but operated by electrical heat and with slightly more intense reduction conditions, sufficient to reduce the zinc but not to reduce appreciable amounts of the iron oxide present in the slag."

The furnace (see also our Vol. VIII, p. 688, December, 1910) is of the Siemens arc type with certain important modifications.

In the smelting operations a certain percentage of carbon dioxide is evolved. This is fatal to efficient condensation. To reduce the percentage of blue-powder and dross to a minimum, or to ensure a high "condensation factor," i. e., a high percentage of metallic spelter made direct to total spelter made, Mr. Johnson passes his reduction gases through a filter of carbonaceous material. This reduces the percentage of carbon dioxide to extremely low limits, lower than those in the gases emanating from the ordinary retort. The condenser that Mr. Johnson uses in conjunction with this type of furnace is simple, yet designed to expose the vapor to the surface of metal, to abstract the heat and to regulate the temperature. Mr. Johnson's condensation factor averages usually somewhat higher than that in the ordinary retort plant. In usual practice from 70 per cent to 80 per cent of the spelter is made direct, and from 30 per cent to 20 per cent from the resmelting of "blue-powder" and furnace products.

Mr. Johnson's slag losses are remarkably low. Usually 99.5 per cent of the zinc content of the charge is reduced and volatilized, while 0.5 per cent of the zinc content passes off in the slag. The remarkable feature of the little 25-kw furnace which Dr. Richards had seen in operation is its great smelting capacity per unit of cubic content. The rate of reduction is about fifty times as fast as in the fireclay retort, and the rate of smelting about five times as fast as in the ordinary lead furnace. Furthermore, with proper manipulation the heat requirements of the charge are reduced to a minimum. Mr. Johnson is now engaged in working out his ideas on a much larger scale. If he is on the right track the ease of smelting and condensing will be greater in his commercially sized unit than in his 25-kw furnace. In the light of metallurgical experience an inventor is on the right track when on increasing the size of his operation his difficulties and annoyances decrease and conversely he is on the wrong track when on increasing the size of his operation his troubles increase.

Entirely irrespective of the merits and possibilities of Mr. Johnson's electric zinc smelting furnace, Dr. Richards believes that we shall see in the immediate future the start of the abolition of the fireclay retort, and that we now see the dawn of the new era of electric smelting in the zinc business.

Condensation of Zinc.

A paper by Mr. F. T. SNYDER, of the Metallurgic Engineering Company, of Chicago, dealt with the condensation of zinc vapor from electric furnaces. If the electric zinc furnace is successful, the design of large zinc condensers becomes of great importance. With electric zinc furnaces it is practical to deliver zinc vapor to a condenser at a rate 300 to 400 times the rate at which such gases reach the standard retort condenser. It is at once evident that the trade-skill basis of design is inadequate and that the opportunity exists for the application of engineering methods to the design of zinc condensers.

Mr. Snyder bases his discussion on the well-known data of the design of the successful small zinc retort condenser and shows how to derive therefrom data for the design of larger condensers. He analyzes in great detail the conditions of temperature and pressure and the phenomena of zinc condensation in the ordinary retort condenser. From these he reaches the following chief conclusions for use in the engineering design of larger condensers.

If we provide 1 sq. cm of clay cooling surface (or an equivalent amount of some other material) for each 0.40 gr. of zinc to be condensed per hour, and if we arrange the thickness of the material of this surface and the temperature conditions at the other or non-condensing side of the material so that 0.21 kg calories of heat will flow through each sq. cm of the surface per hour when the average temperature of the condensing surface is 725° and if we arrange the volume inside the condenser, so that the product of the average longitudinal velocity of the gases in cm per second and the average diffusion distance (corrected to the standard temperature of 864°) in cm,

through which the zinc has to diffuse, is 9.5, then, the design of the large condenser will be on the same basis as the proportions of the standard retort condenser. It is to be kept in mind that only the cooling surface in the condenser that is between 850° and 450° counts in the production of liquid zinc. As this upper limit of 850° depends on the atmospheric pressure, the reduction of the atmospheric pressure with high altitude is to be taken into account for a condenser so located. It is interesting to note in the standard retort condenser, the proportions of which have been determined by many years of "cut and try," that these proportions now in general use give a diffusion factor that is substantially constant throughout the length of the condenser. This means that these proportions represent the maximum commercial economy in the use of the condenser material.

As to further details reference must be made to the full paper, which will be printed in full in the *Transactions*.

The author finally examines the design of one of the large condensers which have formerly been built—that in connection with the Lynen furnace—and shows in what respect this design was deficient.

In the discussion which followed this paper, Mr. Hansen stated that in a continuous run with the Weeks electric zinc furnace at the General Electric Company's plant in Schenectady 1600 lb. of zinc had been successfully and very satisfactorily condensed. Messrs. Bleeker and Quenean also participated in the discussion. In reply to a question of the latter, Dr. Richards stated that the specific yield of Johnson's furnace is 2 tons of zinc per horse-power-year; which is better than at the DeLaval plant in Trollhattan.

Reliability of Electric Furnaces.

Another paper by Mr. F. T. SNYDER dealt with the reliability of electric furnaces for commercial work. This paper had previously been presented before the Chicago section of the society. The conclusions are summed up as follows:

The electric furnace itself has passed from the field of experiment to that of engineering, but the fields of manufacture using the electric furnace products are still experimental.

The electric furnace is technically reliable and will operate continuously with the men and supplies that are available in this country. The details are simple and rugged, and the inherent regulating powers can be made such as to bring it well within the ability of usual plant labor.

The electric furnace is commercially reliable. When installed with the same business care and adaptation to conditions that should be used with other furnaces it will earn a profit on the investment, and a profit that is larger than the normal manufacturing profit in proportion as the field is newer and more open.

Incidentally Mr. Snyder mentioned that he recently examined an electric furnace plant, which started operation on a commercial scale in the summer of 1907 and which is now to be increased fivefold. Substantially all of the original equipment is still in use. The plant, which is in the West, has been operated since its installation by Chinese labor under a white superintendent and neither the superintendent nor the Chinamen know more of electricity than is involved in the opening and closing of circuit-breakers and the reading of ammeters and voltmeters. This particular plant, while not a steel plant, is of interest in showing on many of its operating records a heat development efficiency of over 90 per cent. That is, of the heat equivalent of the energy delivered to the plant by the high-potential electric wires, over 90 per cent is transferred to the material under treatment.

The paper was discussed by Dr. Amberg and Mr. Fitzgerald. The latter referred to the claim of a 90 per cent efficiency and said that as the loss of energy in the transformers, which presumably are used in connection with the high-potential wires, must amount to about 3 per cent, there is left only 7 per cent for the losses by radiation and the various other losses inevitably

associated with work of this kind. "It is not intended to deny the accuracy of Mr. Snyder's statement, but merely to point out that such an extraordinary observation should be at least substantiated with an account of the methods used in arriving at the result."

The Cyanamide Process for Gold.

The first paper called for discussion in the session of Friday morning was the paper of Mr. JOHN COLLINS CLANCY, of the Moore Filter Company, of New York City, on the electrolytic cyanamide process for treating gold ores which was presented before the New York section of the society some time ago and which was published in full in our January issue, page 21. It was discussed by Dr. N. S. Keith and Dr. A. W. Smith.

Dr. Keith gave some principles of the ordinary cyanide process with special reference to Elsner's equation $4\text{Au} + 8\text{KCN} + \text{O}_2 + 2\text{H}_2\text{O} = 4\text{KAu}(\text{CN})_2 + 4\text{KOH}$, to show why and for what purpose the free oxygen is needed in the process, and described some simple experiments demonstrating some of the reactions in the cyanide process. He then criticized rather severely several points in Mr. Clancy's paper, especially the use of the term "protective alkalinity," further the proposed employment of cone-shaped tanks supplemented by blankets for separating sulphides from the gangue accompanying them in the pulp. He also thinks that the solvent of Mr. Clancy is rather complex and that the use of the electric current for regeneration of the solvent is too expensive.

Mr. Clancy's reply will be printed in the *Transactions* of the Society.

Electrolytic Amalgamation.

A paper by Mr. ELMER ELLSWORTH CAREY dealt with "the electrolytic system of amalgamating gold ores." He pointed out the difficulties of ores where crystals of iron pyrites are found in quartz, and within the pyritic crystals are gold particles in a finely divided state. The values in such crystals cannot be recovered on the usual mill plate, as the particles of gold are coated with various substances, preventing amalgamation. The present practice is to separate the pyritic crystals from the crushed ore by various types of concentrating tables. This so-called concentrate is then sent to a smelter, or it is ground in tube mills (100-200 mesh) and delivered to the cyanide tank, where the extraction ranges from 85 to 96 per cent.

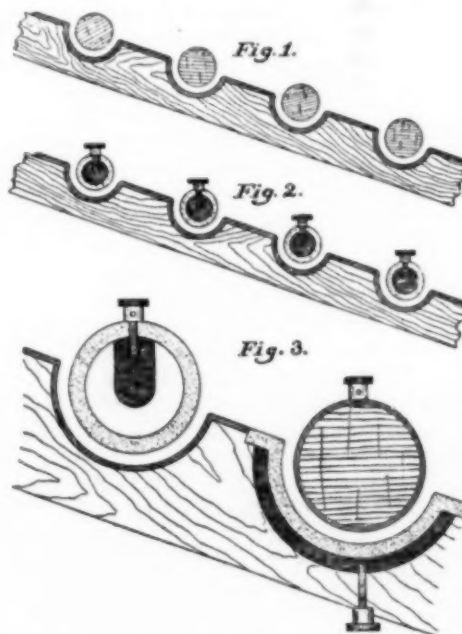
For these treatments Mr. Carey proposes to substitute fine grinding (100 mesh) and electro-amalgamation. An ideal plant for this process consists of some type of rotary crusher, with outside screening, possibly a secondary crushing device to finish the work of the first crusher, and from the crusher the pulp, ground sufficiently fine to release all economic values, is passed over electrolytic amalgamating devices. The released values are recovered in the form of amalgam.

In electrolytic amalgamation, the sole function of the electric current is to deposit hydrogen, sodium, potassium or ammonia in the mercury. The sole function of sodium or potassium is to deoxidize water, and the final work in the chain of reactions is the liberation of nascent hydrogen at the surface of the mercury. As the particles of gold sweep over the electrolytically excited mercurial surface, all substances usually preventing amalgamation are automatically and almost instantly destroyed or rendered inert. Grease is saponified by the caustic soda; oxide coating on gold particles is reduced by hydrogen; in a word, gold particles are cleaned and amalgamation quickly follows.

Hungarian mercury wells are described in Vol. II of Prof. R. H. Richards' *Work on Ore Dressing*; by making the baffle in such wells an anode, using suitable material, and employing an 8 to 12-volt current of high amperage, we have an electrolytic amalgamating device. The objections to the use of such mercury wells disappear when they are electrified, and their extraction efficiency is greatly increased. The interior of such wells must be lined with some very refractory substances.

A simple experiment showing the activity of hydrogen-sodium amalgam and the value of electrolytic amalgamation is to place a piece of plastic sodium amalgam of the size of a pea in a test tube, to add an ounce of water heavily saturated with ammonium chloride, and to test the amalgamating powers of the very curious resultant amalgam by copper and iron wire.

The amalgamator for gold ores consists of a series of electrolytic sodium-mercury cells, followed by another electrolytic amalgamating device in which the values are recovered on silver-plated copper plates of suitable construction. With the mercury wells high amperage may be employed, liberating large volumes of hydrogen, which removes all coatings (oxides, sulphides, grease, talc, silicious coatings, etc.) from the micro-



FIGS. 1, 2, 3. ELECTROLYTIC AMALGAMATION APPARATUS.

scopic gold particles; in the secondary amalgamator the plates offer a large cathode area so that all portions of the pulp are forced into contact with a highly active mercury surface. The supplementary amalgamating device above mentioned consists of a silvered copper plate of suitable width; this plate contains parallel, transverse, semi-cylindrical depressions (grooves, pockets or riffles) the full width of the plate; into these grooves project cylindrical terra cotta cylinders, leaving a $\frac{1}{4}$ -in. clearance, from 3 to 4 in. in diameter; these cylinders contain a graphite core, 1 in. in diameter, connected as an anode.

The pulp passes under the cylinders, and sweeps gently over the curved (cathode) amalgam plate, while gravity, the force of the water and centrifugal force tend to drag each gold particle into contact with the highly excited mercury surface.

Fig. 1 shows a section of a new type of mill plate which Mr. Carey has devised. The sides are not represented. The silver-plated copper plate (being of the usual length of amalgamating plates) contains transverse parallel semi-cylindrical grooves into which fit solid cylindrical wooden baffles; these baffles may also be made of standard piping or casing, from 3 to 4 in. in diameter, with the ends closed. The clearance between the plates and the baffles is from $\frac{3}{16}$ to $\frac{1}{4}$ in. One piece of copper plate may be used, with the proper depressions pressed therein, or, preferably, a number of overlapping plates may be used, each plate containing one or two semi-cylindrical depressions. The plates are held in position by their own weight, fitting closely to the sides, and can be quickly removed from the device for cleaning up. The device may be given any desired grade, and the plates are dressed and operated as the usual mill plate. A mill plate arranged as described will make a

better extraction on the average ore than the usual type of amalgam plate, there being no loss of amalgam.

In Fig. 2 is illustrated an electrolytic mill plate, constructed similarly to the one shown in Fig. 1, which will not only recover all values saved by the standard types, but in addition all free values in silicious pulp and slimes, all values in placer material, beach-sand and all black-sand values are also recovered. The cylindrical baffles are made of terra cotta, and each contains a graphite core connected to the positive lead of a low-voltage generator; the amalgam plates are connected to the negative lead of the generator.

In the first groove or riffle shown in Fig. 3 the water and pulp pass over the amalgam plates as in Fig. 2; in the second riffle of Fig. 3, the amalgam plate connected to the negative lead forms a casing for the baffle, and the pulp stream passes under the mercurial surface, thus bringing the surface of the water into intimate contact with the electrically excited mercurial surface; or a copper cylinder, silver plated, may be used as a baffle, and at the same time act as an amalgamating surface.

A gold-saving device may consist of a series of such riffles as are shown in Fig. 3, arranged alternately; such an arrangement is particularly useful in treating pulp containing gold in a finely divided form, or for recovering values in slimes or in solutions. By screening placer material to 10 or 12 mesh, and passing the undersize of electrolytic amalgamating sluiceway of suitable length, all fine, rusty, float, coated, and greasy gold is recovered.

In certain classes of base ores it may be necessary as a preliminary measure to treat the pulp for 30 minutes by electrolytic pan amalgamation before passing the pulp over the electric sluice; and for ores containing gold in chemical combinations (sulphotellurides, etc.) a preliminary roasting may be required.

In the discussion of Mr. Carey's paper, Dr. Keith said that, while the idea of electrolytic amalgamation was old, Mr. Carey had improved on the apparatus.

Electrolytic Corrosion of Electroplated Objects.

A paper by Prof. WALTER S. LANDIS, of Lehigh University, referred to the observation that gold-plated steel pens corroded far more rapidly than plain steel pens. This is due to the fact that the friction of the pen point on the paper rapidly wears off the plating on the point, thus exposing the steel; an electrolytic couple consisting of steel, ink, and gold is thus set up and corrosion results.

The e.m.f. of the couple was measured between a fresh gold-plated pen and a like pen, stripped of its gold plating, in different kinds of ink.

"While the corrosion of the plated pens is not a matter of great commercial importance, yet there is to be gained from the experience a certain wholesome lesson on the application of electroplating to the protection of less noble metals: Do not plate with a nobler metal a material that is likely to be subjected to wear on one spot and which spot is to be moistened with liquids. For, as soon as the plating is worn through on that spot, accelerated corrosion will take place, and in the end the resulting corrosion will be far worse than without the plating."

The paper was discussed at some length by Messrs. Murphy, Walker, Hering, Richards, Hogaboom, Kohn, and Willard. The latter pointed out that nickel-plated iron or steel will invariably rust in a moist atmosphere. Not only the weight of the nickel deposit, but also its continuity are of primary importance, and it seems impossible to insure absolutely the latter in commercial practice.

Electrolytic Iron Refining.

A paper of Prof. CHARLES F. BURGESS, of the University of Wisconsin, which had already been presented before the Chicago section of the society, dealt with electrolytic refining as

a step in the production of steel. The question is: Can iron, refined electrolytically by his process (our Vol. II, page 183), be made an industrial product? Iron can be refined electrolytically almost as easily as can copper. Whether there is a field of usefulness for such iron depends upon whether electrolytic iron has superior qualities due to purity or physical condition, and whether it can be procured at low cost.

From the standpoint of purity it must compete with some notable metallurgical developments which have resulted in the product such as is being made by the American Rolling Mill Company in a basic open-hearth process. The electric furnace is another factor which is contributing largely to the control of the composition and purity of iron alloys.

The chief source of commercially pure iron has been, and perhaps now is, the high grade Swedish and Norway iron, used largely as a base material for high-grade crucible steel. The analyses of this material usually indicate a high purity, though frequently and erroneously calculated by difference after determining carbon, sulphur, silicon, phosphorus and manganese. It is not uncommon to find oxides and slag to the extent of 2 per cent in this material, and this impurity undoubtedly may have an influence on the resulting alloys made from it.

Electrolytic iron can be produced with a purity as high as 99.97 per cent and perhaps even better, using extraordinary precautions. This record has been made by using the best commercial grades of pure iron as anodes. A few hundredths of a per cent of purity must be sacrificed in using anodes of mild steel or other less pure materials. Further the uniformity of this electrolytic iron should be of importance for its uses.

Using an electrolyte containing 40 grams of iron per liter in the form of ferrous sulphate together with 40 grams of ammonium chloride, it has been found possible to conduct a continuous refining operation for many months at a current density of 6 amp to 10 amp per square foot of cathode surface, and at a potential difference of about 1 volt. The current efficiency is very close to 100 per cent, as it is in copper refining.

This leads to the calculation that 1 kw-hour will refine 2 lb. of iron; or a cost for power of $\frac{1}{2}$ cent per pound is attainable. The costs for labor, solution maintenance and fixed charges are estimated to be not greater than the power costs, making a cost of refining of about \$20 per ton. Assuming the anode material to be mild steel costing \$35 per ton, the cost of electrolytic iron would be in the neighborhood of \$55. These approximate calculations indicate that this material might well compete in price with high-grade Swedish iron.

Among the properties of electrolytic iron which may give it some added usefulness is its content of hydrogen and the brittleness which results from this occluded gas. This hydrogen may be of some service in reducing oxides in a melt. The brittleness of the electrolytic iron before the hydrogen is driven off makes it easy to break it up into pieces suitable for introduction into the steel crucibles.

Unsolved Problems in Electroplating.

A paper entitled "Some Unsolved Problems in Electroplating" was presented by Mr. GEORGE V. HOGABOOM, secretary of the National Electroplaters' Association. He pointed out that electroplating has been looked upon more as a trade than a science, and that its development has been left to the practical man, guided only by "rule of thumb." An electrochemist in the plating room of a factory is so rare that it probably can be said without fear of contradiction that they can be counted on the fingers of one's hands. The need to-day is mutual co-operation between scientific electrochemists and practical platers in solving their problems and developing new ideas.

In the discussion of electroplating problems, it must be borne in mind that a mere deposit of a metal is not all, but that the deposit must be soft and smooth and lend itself to a decorative process; the anodes should be capable of being reduced easily; the electrolyte must offer little resistance to the electric current,

and, last, but not least to the plater, who hears it so often that it becomes a part of him, the cost must be nominal.

The automobile industry has brought about, more than anything else, the need of a heavy deposit of brass. At present this is done in a solution of cyanide of copper. The deposit is not only slow, but unsatisfactory, because of what is known as "spotting out"—a discoloration in spots which appears on the work after it has been polished and lacquered. Deposits on cast metal give the most trouble. It is probably caused by the acids or alkaline solutions being absorbed in the pores of the metal, or in the small blow-holes, and the deposit covering these holes partially, leaving minute holes through which the solution oozes out. Several remedies have been suggested and tried, such as boiling out in some neutralizing chemical solution, placing in a drying oven for several days, but a satisfactory remedy has not been found.

An acid brass solution would be a great advantage. There is an acid copper and an acid zinc solution, but no acid brass electrolyte. The difference between the deposit from a cyanide and a sulphate of copper solution well illustrates the advantage of having an acid brass solution.

Tin.—The formula for a tin solution published by Roseleur is the most generally used to-day, as little, if any, improvement has been made upon it, although a good solution which would give a heavy deposit is much desired. In Roseleur's solution the electrolyte is not replenished by the anode, but by the constant addition of a concentrated solution. This should be overcome, and would be appreciated by manufacturers of tinware.

Aluminium.—While several solutions have appeared from time to time for plating upon this metal, none of them are in general use, and a good electrolyte that would deposit gold, silver, brass or copper so that it would stand burnishing and not peel off in time could be used.

Nickel.—The successful removal of a deposit of nickel from another metal without affecting the latter has not been accomplished.

To give all the unsolved problems in detail would make a lengthy paper, and a simple statement of those most desired will be given:

An electrolyte that will remove the fire-scale from brass; also one that will produce a bright or a matte surface in place of using the present acid dips.

An electric cleaner that will saponify the grease and take it into solution instead of driving it to the top, where it has to be constantly removed to prevent it adhering again to the work as the latter is removed from the solution.

A heavy deposit of lead on the inside of iron pipes, to prevent rapid corrosion.

A method to coat electrogalvanized iron or steel with decorative metals without destroying the rust-resisting properties of the zinc.

An alkaline nickel-silver solution that can be worked with a low voltage.

A method of etching steel without destroying a resistance film of gelatine.

Some alkaline substance that would replace cyanide of potassium. This would be universally welcomed.

For the above suggestions the writer is indebted to 100 different platers, who were kind enough to answer a request for unsolved problems. It may be interesting to note that 80 per cent of them requested an acid brass solution.

In the discussion Mr. Lidbury said that the list of unsolved problems was quite interesting but that it would seem that at least half the problems were easy of solution, if electroplating shops would employ competent electrochemists. Dr. Walker said that in their jealous secretiveness many modern electroplaters (and some other manufacturers) compared with the old alchemists, but that progress depends on the free interchange of ideas.

Polarization.

A paper by Dr. OLIVER P. WATTS, of the University of Wisconsin dealt with polarization in the relation to the decomposition pressure of electrolytes. Dr. Watts endeavored to show that the principal factor in causing the phenomenon of the decomposition voltage as observed in electrolysis is not the resistance of a gas or other film upon either or both electrodes, but that it is due to a counter e.m.f. which is produced at the electrodes as a result of the action of the impressed e.m.f. This counter e.m.f. is referred to as polarization.

By the introduction of a third electrode and the measurement of the differences of potential between this and the anode and cathode, it is possible to ascertain what proportion of the total polarization is contributed by the anode and what by the cathode. The most satisfactory reference electrode to use for this purpose is the normal calomel electrode. The results of various tests are given in which the total polarization as well as the anodic and cathodic polarizations separately were determined.

The source of the counter e.m.f. is of the same nature as the e.m.f. of any primary or storage cell, viz., it is the result of an unsymmetrical electrochemical system, consisting of two electrodes in one or more electrolytes. Before electrolysis the electrolytic cell was symmetrical consisting of like electrodes in an electrolyte of uniform composition, concentration and temperature, and therefore the e.m.f. of the cell was zero. With copper sulphate and platinum electrodes the application of an e.m.f. causes the system to become unsymmetrical, by the deposition of copper at the cathode and oxygen at the anode. The e.m.f. of this little copper-oxygen storage cell, which, as in all storage cells, is opposite in direction to the charging e.m.f., continues to increase in magnitude, as more and more copper and oxygen are deposited, until its e.m.f. equals the impressed e.m.f., when the flow of current ceases. All this may occupy one or two seconds. With each increase of impressed e.m.f. this process is repeated, until the value of the impressed e.m.f. exceeds that attainable by the little storage cell; then a permanent current flows.

This refers to insoluble electrodes. With soluble electrodes the concentrations of the electrolyte are changed right at the electrodes and this change of concentrations produces a counter e.m.f.

The final conclusions of Dr. Watts' paper are as follows:

Polarization is responsible for the phenomenon of decomposition pressure in electrolytes.

The total polarization may be resolved into two components, the one at the anode, the other at the cathode.

Since it is polarization which prevents the flow of current in accordance with Ohm's law, the residual current is the equivalent in current of the rate of depolarization of the electrodes by the electrolyte.

Moreover, if electrolysis causes a change in the material of an electrode, or of the electrolyte in immediate contact with it, the polarization at the electrode is large. This is the case with an insoluble anode, and usually so for a cathode whose position in the electrochemical series is far from that of the element which is deposited upon it by the current.

If the chemical composition of the electrode and of the electrolyte in contact with it are not changed, the polarization will be small. This occurs with a soluble anode and with a cathode of the same material as that deposited by the current.

The paper was briefly discussed by Mr. Hering and Dr. Richards.

Electrical Heating as a Means of Prevention of Superheating.

A paper by Dr. J. HOWARD MATHEWS, of the University of Wisconsin, described a modification of the method proposed a number of years ago by Bigelow for the determination of molecular weights in solution by elevation of the boiling point.

The modification consists primarily in the arrangement of the heating spiral, in the use of a heavier heating current and in the more accurate control of the heat thus supplied. With the apparatus as described, and with the precautions enumerated, it was found possible to make molecular weight determinations with a degree of accuracy heretofore unattainable. The use of glass bead in the boiling chamber has not only been shown to be useless as a means of prevention of superheating, but is a positive detriment.

A long series of determinations were then made to ascertain whether the slight superheating effect experienced would be the same when wires of different materials were used for the heating elements. It was shown that German silver wire produces a much greater degree of superheating than any of the other wires used. Wires of the resistance materials known as nichrome, advance, manganin, and monel showed but little tendency to superheat. The tendency to superheat the liquid was not found to be dependent in any way upon the specific resistance of the heating element. German silver wire when rolled out in the form of a ribbon and well roughened with a file showed about as little tendency to superheat the liquid as did wires of platinum or of the other materials above enumerated. A covering of oxide over the surface of a smooth German silver wire seemed to produce no effect upon the tendency to superheat.

Bifunctional Accumulator.

Mr. A. O. TATE, of Toronto, Ont., Canada, then presented a paper on his new "bifunctional accumulator." Nothing is changed in the chemistry of the ordinary lead accumulator. Mr. Tate's work has been chiefly along mechanical lines. The positive and the negative elements are contained in the same plate on both sides of it, hence the name "bifunctional." The chief mechanical feature is the use of short narrow conducting strips, separated by perforated celluloid strips. The slight depth of the active material permits very quick charging. Other claims for the battery are very uniform current density, insurance of good contact between active material and support, and avoidance of sulphating.

In reply to a question by Dr. Brown, Mr. Tate stated that the battery gives 11 to 12 watt hours per pound of complete battery in service.

Production of Aluminium in Laboratory.

Dr. H. K. RICHARDSON, of the Pennsylvania State College, presented a paper on "Some Observations on the Laboratory Production of Aluminium." The paper gave an account of runs made by students during the regular scheduled laboratory periods in electrolytic deposition of aluminium. The author follows in many respects the method of Neumann and Olsen (this journal, Vol. VIII, p. 185).

The instructions given to the students are as follows:

Make 4 kg. of a mixture:

Alumina 20 to 15%

Natural cryolite 80 to 85% old charge

Melt up 3 kg. of charge at once. Add the remainder as the bath becomes diminished.

Remove the heating carbon as soon as the bath is thoroughly fluid.

Add alumina to bath every 30 minutes. Quantity to be calculated on assumption of 50 per cent current efficiency.

Use anodic current density of 3 amperes per square centimeter.

If anode effect causes trouble, i. e., current suddenly drops

(1) Open and close circuit quickly

(2) Add a charge of alumina

(3) Tap electrode sharply

(4) If none above effective, try adding cryolite.

If voltage gradually rises at constant current, add, in order named, alumina, mixture, or cryolite, whichever brings the voltage down.

Keep crust broken on at least one side of electrode. Crushed coke around the electrode will tend to keep crust soft.

Take voltage and current readings every five minutes.

The results of the tests given in the paper show that a satisfactory laboratory run can be made upon aluminium, following instructions as given above. The best results are to be expected under the following conditions:

Mix: 85 per cent natural cryolite; 15 per cent alumina.

Current Density: Approximately 3 amperes per sq. cm. of anode surface.

The anode effect appears to consist of two kinds:

(a) Gaseous envelope which opens the circuit. This can be remedied by opening and closing the circuit or tapping the electrode.

(b) Non-wetting of the electrode, thereby causing numerous small arcs to form from electrode to electrolyte. This causes the voltage necessary to be increased, and appears to be remedied by addition of alumina or cryolite, although it is present in some degree during the entire run.

In the hands of students, using the apparatus of the author, and following the instructions as closely as students usually do, an ampere efficiency of about 60 to 70 per cent may be expected.

Dr. Richardson's paper brought out quite an extended discussion. Dr. Jos. W. Richards stated that the value of 2.8 volts, given in the paper as the decomposition voltage, refers to the decomposition of the alumina, but the cell is to be credited with the voltage due to the oxidation of the carbon. Thus the theoretical voltage comes out as 2.25 volts. This agrees with practical experience. The energy efficiency of Dr. Richardson's tests is then less than 26 per cent. This agrees with the energy efficiency in practice, where it is 25 per cent. 75 per cent of the energy is consumed in keeping the bath at the right temperature. This fact emphasizes the importance of reducing heat conduction and radiation losses.

Dr. Richardson further pointed out that a high current efficiency of over 90 per cent is possible only with low temperatures. In practice a current efficiency between 75 and 80 per cent is attained, so that there is a loss of 25 to 20 per cent due to redissolving of aluminium in the fused bath.

Mr. A. H. Cowles doubted whether there is a redissolving of aluminium, except when there is a voltaic couple formed by the carbon walls and the aluminium.

Dr. Richardson replied that the dissolving of the aluminium was not due to a voltaic couple, but was a case of simple solution. Whenever a fused salt is electrolyzed there is a tendency for the metal set free to dissolve back into the fused bath, and this tendency is the greater the higher the temperature. If it was possible to work with the aluminium bath near the freezing point of aluminium, nearly 100 per cent efficiency could be obtained. But there is a practical reason, due to specific gravities, which prevents this. If the salt is cooled near to the melting point the aluminium floats on the bath.

There was some further discussion, especially on the analogous case of sodium, in which Mr. Cowles, Dr. Walker and Mr. Lidbury participated.

Electrolytic Meter.

A paper by Prof. FRANK C. MATHERS and ALBERT F. O. GERMANN, of the University of Indiana, dealt with a mercurous perchlorate electrolytic meter. Silver and copper are the metals generally deposited in coulometers or voltameters, but mercury has two great advantages for this purpose: it is liquid and has a very high electrochemical equivalent. The difficulty seems to have been in the past with the electrolyte to be employed.

The authors recommend very strongly mercurous perchlorate and give an account of their experiments with this electrolyte. They describe the preparation of the materials, conductivity experiments, and coulometer experiments, and sum up their results as follows:

The advantages of mercurous perchlorate solution as an electrolyte for meters and coulometers are:

The ClO_4 radical is exceptionally stable and is absolutely unchanged by electrolysis.

Mercurous perchlorate is very soluble in water, and the solutions thus formed are entirely free from any decomposition.

Mercurous perchlorate solutions containing free perchloric acid have very high conductivity, such that a very high current density may be used in electrolysis.

The amount of mercury deposited may be very rapidly determined by measurement rather than by the much slower method of weighing.

The deposited metal is in such form that it may be transferred to the anode for further use without any treatment whatever.

Equivalent quantities of electricity deposit from two to six times greater weight of mercury(ous) than of the other metals. This gives greater accuracy.

The paper was discussed by Mr. Schluederberg, who spoke of the reasons which have restricted the use of electrolytic meters in commercial practice. In this country they are not used at all, but in Europe to a certain extent in small direct-current installations, their chief advantage for small installations being their cheapness. Mr. Hering and Dr. Sharp also participated in the discussion.

Electric Discharge Through Gases.

Dr. LOUIS A. PARSONS, of Johns Hopkins University, presented a paper giving an interesting and concise summary of the experimental work which has been done during the last few years by many experimenters on electric discharges in gases at reduced pressure.

He described the phenomena which have been experimentally established, and summarized the conclusions which can be drawn from the experimental evidence on the nature of electricity and matter and especially on the fundamental units of negative and positive electricity.

The paper was discussed by Dr. Whitney and Dr. Walker, who emphasized how much could be done by research work in universities and colleges along scientific lines.

Electrolytic Transfer.

A paper by Prof. JOS. W. RICHARDS, of Lehigh University, discussed the mechanism of electrolytic transfer with special reference to the phenomena in fused salts. The author emphasized the frequent deviations of a chemical compound from the simple or fixed atomic proportions. For instance, if iron pyrites FeS_2 is melted, sulphur leaves it and at a low temperature one has Fe_2S_3 , Fe_3S_4 , Fe_4S_5 , or various approximations to FeS .

By an increase of temperature one passes by insensible gradations all the way to Fe_2S , and at electric furnace temperatures perhaps beyond this.

A chemical compound in absolutely atomic weight proportions is practically unknown in the whole class of melted mattes. In general a rather extensive study of fused salts and compounds leads him to regard fixed atomic weight proportions as the exception rather than the rule, in practical work.

If a tube full of smelted PbS is electrolyzed, lead is set free at one end and sulphur at the other. Now, Dr. Richards argues, the deficit of lead at the cathode is quickly distributed by diffusion throughout the whole electrolyte, while the deficit of sulphur at the anode is similarly rapidly distributed throughout the electrolyte. This distribution of the two deficits at the two electrodes is made possible by the known solubility of such intermediate products in the normal salt, and amounts to a virtual transfer of the two constituents from the whole mass of the electrolyte to the electrodes.

According to this view, the transfer in electrolysis is essentially solubility and diffusion of these slightly abnormal compounds formed by electrochemical action at the two electrodes. Dr. Richards therefore claims that the electrolytic transfer

occurs as the result of electrolysis and is not the preexisting mechanism of electrolysis.

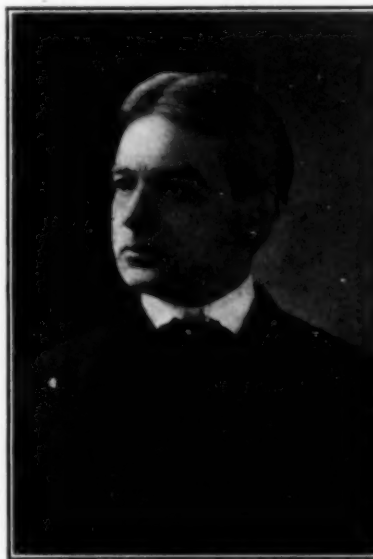
In the discussion which followed Dr. Parsons suggested that to investigate the nature and mechanism of electricity one should begin with the simplest case, the transfer of electricity through gases, where the phenomena are already complicated enough, although much less in solutions.

Presidential Address.

In the evening of Friday a joint session with the New York section of the American Chemical Society was held, at which the retiring president, Dr. WILLIAM H. WALKER, of the Massachusetts Institute of Technology, presented his address on "Chemical Research and Industrial Progress."

Within the last few years research has become a word to conjure with. The new field of human endeavor epitomized by the word research represents a change in the method of finding truth rather than the intensity of desire to know the truth. It is understood now that a search for truth can only reach its goal through intimate contact with the things themselves, and an accurate determination of the facts concerning them.

In former ages the dictum of Aristotle that "industrial work



W. H. WALKER, RETIRING PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY.

tends to lower the standard of thought" prevailed, and it is to this want of sympathy that we must ascribe the fact that the old historians failed to note the discovery of even the most important early chemical processes, while they gave detailed accounts of those men who advanced mere speculations and taught untenable opinions on the constitution of the universe.

To find the philosopher's stone was the goal of the alchemists; their labors were not a search for the truth, but for gold. It may be a long step from the work of the alchemists to modern industry. But there may be something in common between the work of the ancient investigators and their influence on civilization, and chemical research of to-day and industrial progress.

The alchemists did not make material progress in their methods in centuries. The explanation of this is to be found in the secrecy which they at all times maintained. There was no accumulation of knowledge or experience and each succeeding investigator continued to grope around in darkness.

The change came in the thirteenth century with Roger Bacon who, in his treatise, showed that phenomena which had been attributed to supernatural agencies were in fact due to common and natural causes. He is to be regarded as the intellectual originator of experimental research. Just as knowledge was sought after for its own sake, and in proportion as there was free and honest intercourse among the investigators of the time, just so rapidly was real progress made.

But for many years after the broad generalizations upon which modern chemistry is founded were well established industry did not profit much by scientific work. One hundred years ago the men who melted the iron and copper, the lead and zinc knew little of the principles underlying their practice. Leather was tanned, woolens, cottons and silks were dyed, porcelain and glass were made without the aid of those who alone knew the chemistry involved.

It is not that scientific men took no interest in the manufacturing industries, for we can recall the great work of Liebig for agriculture, and the immense amount of analytical chemistry which is the foundation of industrial chemical practice, but these were times when the advance in chemical knowledge was far ahead of the industries on the success of which our material comforts depend.

A real attempt to apply chemical knowledge and methods commenced about 1850. It was in 1856 that Perkins made the first synthesis of a coal-tar color, and founded the industry which has become the most remarkable example of applied chemistry that we have. In 1855 Bessemer introduced his revolutionary process for making steel, made possible by the clear understanding of the nature of steel through improved analytical processes.

The last fifty years may be said to be characterized by the production of men who combined the ability to appreciate and enjoy work in science for itself alone, but also possessed the ability and inclination to apply their chemical knowledge and training, and to make results of past generations of pure scientists of ever increasing service to humanity.

But within the last ten or fifteen years we have seen a third kind of chemical activity develop, namely, a class of men who while possessed of the ability and love of science which characterized the leaders in pure science of old, yet are not handicapped by the doctrine of Aristotle that contact with industry contaminates thought. This movement is seen in the tendency of great industrial organizations to establish research laboratories within themselves, and in the willingness of educational institutions to maintain research work in these fields of chemistry which are immediately applicable for industrial practice.

For the purpose of further studying the relationship existing between chemical research and industrial progress, Dr. Walker divided this kind of chemical activity into three classes. First, there is that which for want of a better term we will call original work in pure chemistry; second, there is the work of the so-called industrial chemist, the man who primarily applies existing chemical knowledge to the accomplishment of specific ends, and third, there is research work in what again for want of a better name he calls applied chemistry.

The environment of pure science has in the past been academic; the great investigators were teachers. This is so in America as in Europe. But there is a very different attitude shown toward men of science here and in Germany, for example.

In Germany everybody trusts science, even the Government. The Germans are accustomed to consult a scientific expert before going into a new business. That is the reason why, as Oswald says, Germany has managed to put more brains into her goods and has assumed its present position in the world.

Our American industries have flourished very well, it is true, but rather in spite of a lack of scientific aid, than on account of such aid. We have grown vastly satisfied with our achievement, but we might pause now in our self-congratulation long enough to inquire whether the things we are doing cannot be better done.

There is a mutual obligation existing between our educational institutions and our industries. The former must continue to increase their facilities for the research, which has made the German universities the avenues through which German civilization and industry have been brought to the point that we find them to-day.

On the other hand, the industries should not fail to recognize that progress based alone on industrial prosperity is but apparent progress, and that a sound civilization depends not only on conditions which make for material comfort, but on the culture which comes from an education in the broad sense that scientific research implies.

The great tendency of our times is toward service. This is seen in every sphere of human activity.

There is with scientific men a general awakening to the fact that the highest destiny of science is not to accumulate the truths of nature in a form that no one else but the select few can utilize, but that the search for truth can be combined with a judicious attempt to make the truth serve the public good. Thus the distinction which has existed between the terms pure science and applied science is rapidly falling away. An attempt to define these two kinds of science reveals the fact that this distinction is a general impression rather than a clear statement.

According to a fundamental law of psychology thought tends to pass over into action. Applied science is nothing more than the realization of this, and is thought in action. Force does work only when in motion, so are ideas of value only when carried into effect.

But the carrying of an idea into practice is not always an easy matter. It is frequently much easier to make a discovery or to develop a new fact than it is to make of such a discovery a serviceable reality. For example, the reactions underlying the ammonia-soda process were well known as scientific facts for many years, but this knowledge did not benefit the world until the genius of Solvay made through it purer and cheaper soda available. Cavendish long ago discovered that an electric spark produced nitric acid in the air, the world waited until but a few years ago in order to profit by his knowledge. It was then that the researches of Birkeland and Eyde made of the idea an industrial process.

Men who can interpret the scientific results already available have been of incalculable value in the growth of our industries, and there will ever be a field for this type of chemical activity. In fact it is just here that we find the faith of the Germans in science bearing fruit. In America there is a national lag in the application of new scientific data to every-day problems. We as a people are so wonderfully keen in developing mechanical ideas when once they are presented, that the marked lag in the acceptance and application of chemical principles is remarkable.

The industries themselves are frequently to blame for disappointing results which sometimes are met in an attempt to introduce scientific methods into their works. They employ a so-called chemist, without inquiry as to whether he has had the kind of training that could be expected to fit him for the work he is expected to do. They furnish him with a meagre equipment and then expect revolutionary results. When these are not forthcoming they exclaim in disgust: "There is no money in chemical control, or chemical research, we have tried it."

But there are signs of a change. The most distinct one is the impatience shown by some of the more enterprising manufacturing concerns, to wait for scientific facts to be discovered by others, and their willingness to establish research laboratories within their own organizations; to actively enter the field of research in applied chemistry.

How does research in "applied chemistry" differ from research in "pure chemistry"? Dr. Walker made the distinction clear by an analogy. The development of research in a science may be compared to the exploration of a new country. New roads are to be laid out, tunnels bored and bridges built, in other words, new problems solved. This may be done in two ways. First, constructive work may be undertaken wherever an interesting problem presents itself, without regard as to whether there is a demand for such structure or not. As a rule, the builder is under no great pressure to get the structure com-

pleted. This may represent the method of pure chemistry, and the great advance in chemical knowledge of the past was made almost entirely by boring just such tunnels and building just such bridges. The industries have used these structures when they could, or when some second builder could adapt them to use.

Research in applied chemistry differs from that just described only in this or it needs differ only in this, that when a problem is to be solved, a bridge to be built, the work is undertaken at a point where there is a demand for its use; where people are waiting to cross over so soon as it is finished. The method of building is no different, the difficulties no less. The fact that the bridge is to be used makes the work of the building no less dignified, nor is it possessed of less pleasure.

Why is there not the respect for this kind of work as when a bridge is built with the knowledge that it may not be used for an indefinite period? Why does an eminent writer a few months ago lament the fact that there is not more research "uncontaminated with the worship of usefulness"? Why does usefulness contaminate? Dr. Walker thinks it lies in this. The investigator of pure science works in the broad daylight, throws his product open for inspection, and invites all to come and use it when they can. In applied chemical research the spirit of the alchemist tends to creep in. The builder keeps his materials of construction and his designs a secret, and so boards up his bridge that those who cross over it cannot see how it is built, nor profit by his experience. The moment a thing becomes useful we become jealous of its possession; we become narrow in our horizon; we sell our scientific birthright for a mess of pottage; we become alchemists.

There is a heavy moral obligation on the part of large industrial organizations having fully equipped research laboratories to contribute their share to the advance of the world's knowledge. An obligation to see to it that they do not become saturated with the spirit of alchemy. They have well-stocked libraries and are provided with all the current periodicals; they profit by all the scientific work which has been done and is being done. This is as it should be, and such firms are to be commended for their progressiveness. But is there not a reason why such laboratories should do their part in adding to the sum of available knowledge? There is in every laboratory much work which could be published while the interests of the corporation are conserved.

Germany is very justly held up as a shining example of marvelous industrial progress and prosperity. A very great deal of the credit for her present position is due to her splendid educational system. But no small factor in her national progress is the helpful attitude which her industrial organizations take toward the publicity of scientific data. The individual does not suffer, while Germany both from a scientific and an industrial standpoint is rapidly advanced.

But too often with us the president and his board of directors are alchemists; they fail to see why if they pay the salaries of the research men, they should give the public or their competitors any part of their results. They exclaim "what has posterity done for us"? They would have their laboratories remain the secret chambers of the alchemists, and continue to improve their methods of changing baser materials into gold, without regard to the obligations which they owe their fellows.

It is to the men who form the working force in our industrial laboratories that we must in a great measure look for making our national scientific societies the power for industrial progress which they ought to be. But it is this general disinclination on the part of industrial concerns to allow their chemists to disclose in any measure the results of their work by contributing papers for the meetings or in entering heartily into the discussions that makes this realization difficult.

This is to be deeply lamented and we believe it is the fundamental mistake; a short-sighted policy which can but react upon industrial progress as a whole. We cannot operate a scientific laboratory as we would do a factory. The conditions

of maximum productiveness are not found in an atmosphere of selfish rivalry.

It requires no extensive mathematical calculation to prove that the manufacturers themselves would be the ones to profit by more liberal treatment of the results of scientific work.

Of one hundred manufacturing concerns each one would give but 1 per cent of the whole contribution, while he would receive the remaining 99 per cent. He could not in the long run be the loser. But of vastly more importance he would feel and know that his organization was taking part in a world movement toward that increase of human knowledge upon which all real progress depends. The greater sense of satisfaction, the greater success even of an industrial organization lies in a fuller, freer, more generous publicity of the scientific results of their laboratories.

Would that we might benefit by the experience of Solomon, King of Israel, when asked "What shall I give unto thee?" replied "Give me knowledge and wisdom," and he answered, "Wisdom and knowledge are granted unto thee, and I will give thee riches and wealth and honor."

Surface Action and Electrochemistry.

Dr. HARRISON E. PATTEN, of the Bureau of Soils, U. S. Department of Agriculture, Washington, D. C., then lectured on the subject of the relation of surface action to electrochemistry. In a brief introduction he outlined the general form of treatment as follows: First, a definition of surface tension as the first derivative of surface energy with respect to surface change; second, a consideration of the general equations of surface changes following the treatment given by J. Willard Gibbs; third, an extension of these equations with the assistance of a cyclic process to surfaces having an electric charge; fourth, the application of the general equation developed in the third section to electrocapillary phenomena, to migration of suspended particles, and to electric osmose; fifth, the relation of absorption phenomena to electrocapillary phenomena, to settling of suspensions, to formation of deposits, and to the behavior of disperse systems in general.

The lecture was illustrated with slides, so that a concise survey of the numerous mathematical and physical factors entering in was given in a short space of time. The lecture will be printed in full in the Transactions.

Electric Iron and Steel Furnaces.

At the Saturday morning session two papers on the electrometallurgy of iron and steel, previously presented before the Chicago section of the society, were called up for discussion. The first was a paper by Mr. JAMES LYMAN on "The Electric Furnace for the Manufacture of Iron and Steel," describing the Frick electric reduction arc furnace for smelting iron ore, the Frick induction type furnace for refining iron and steel, the Heroult furnace, and induction electric furnaces.

Electric Steel Refining at South Chicago.

The next paper by Mr. C. G. OSBORNE, of the Illinois Steel Company, of South Chicago, Ill., gave an account of a few experiences with the 15-ton Heroult electric furnace at South Chicago at the Illinois Steel Company's works of the U. S. Steel Corporation.

The paper first gives a description of the furnace. This particular furnace was described and illustrated in some detail in our Vol. VIII, page 179. Further details are here given from Mr. Osborne's paper.

The furnace shell is of plate steel, 1 in. (2.5 cm.) in thickness, riveted together. The outside horizontal cross-section plan is approximately that of a complete circle of 13½ ft. (4 meters) in diameter, with two flattened portions situated at the front and back respectively.

On the bottom of the furnace, within the 1-in. plate, and next to it, one row of magnesite brick, laid the 4½ in. (11.5 cm.) way, is placed across the flat portion.

The side walls of the furnace are vertical and consist of two rows of magnesite brick, laid the 9-in. (22.5 cm.) way, giving

a thickness of 18 in. (45 cm.) of magnesite brick. These solid magnesite brick walls extend up to the furnace roof.

The bottom "proper" of the furnace consists of dead-burned Spaeter magnesite to a depth of 12 in. (30 cm.) at its thinnest point, which is, of course, at the extreme center. From this thinnest point the bottom slopes gradually upward so as to form a portion of a sphere 7 ft. 2 in. (2.15 meters) in radius.

This bottom was put in in the following manner: Dead-burned and carefully ground Spaeter magnesite was mixed with basic open-hearth slag in the proportion of four of magnesite to one of open-hearth slag. To this mixture, sufficient tar was added to make the mass sufficiently plastic to enable it to be tamped into the furnace in the usual manner. The entire depth of the bottom was tamped in this way. Next, the furnace was filled with wood, dried out for about 48 hours, and then filled with coke, and the electrodes lowered and the current turned on. In this way the bottom was fluxed into place.

The furnace roof is of silica brick 12 in. (30 cm.) in thickness.

The roof is made up on a movable ring. This ring is fitted with a top and bottom angle iron to take a skew-back brick, and then from this the arch is spanned across the 10-ft. (3 meters) interior of the furnace with an 8-in. (20 cm.) rise. The bricks are set in circles parallel to the steel ring, the usual wooden wedges being placed here and there to take care of the subsequent expansion of the brick. Holes for the electrodes are left in the roof by means of templates placed in position. The bricks are held in position around these holes by their lateral pressure.

There are five doors, two on each side of the furnace, and one in front over the pouring spout. These doors are of cast iron, lined with clay brick, laid the $4\frac{1}{2}$ -in. (11.5 cm.) way. They work in the usual groove arrangement, and are operated by steam pressure of about 150 pounds (11 kg. per sq. cm.). The front door over the pouring spout is an exception to this, being operated by hand with a counter balance.

The three electrodes are let down through the roof in the form of an equilateral triangle, each side of which is 5 ft. 2 in. (1.55 meters) in length, the apex of this triangle pointing directly east, that is, toward the back of the furnace. The center of this triangle coincides with the center of the furnace roof.

There are, of course, three separate holders, one for each electrode. Each holder is constructed of a solid copper casting bolted directly to the bus-bar. In front, these holders are split and joined with a right and left screw, which enables the holder to be opened or closed at will. The holders are designed to carry a 24-in. (60 cm.) electrode, but by means of contact blocks to fill, any smaller-sized electrode can be employed.

The weight of the electrode is supported by the chains. These chains run back over pulleys to the drums at the back of the furnace. These electrodes are kept in alignment by vertical guides.

The electrodes are regulated by individual motors placed at the back of the furnace. These motors are attached by gears to the drums. The regulation is by hand, by controllers, or by an automatic device.

The operating platform of the furnace is about 9 ft. (2.7 m.) from the level ground. Around the furnace on this platform, at convenient points, bins are placed for the miscellaneous materials used in furnace operation.

The front part of the furnace platform opens up to allow a ladle to be hung in position when the furnace is tapped and for any miscellaneous work in the pit.

The power for the furnace is generated by dynamos having as prime movers reciprocating gas engines, reciprocating steam engines, high-pressure and low-pressure turbines. It is three-phase, 2200 volts and 25 cycle.

At the electric furnace it is stepped down by means of three 750-kw transformers to the voltage of the furnace. These transformers are so arranged with switches that the primary

turns may be altered to give a secondary voltage of 80, 90, 100, 110 volts as desired. Ordinarily 90 volts is used.

The entire building is spanned by a 50-ton crane.

The pouring platform is situated to the south of the furnace. It is 30 ft. (9 meters) long, and enables eight molds to be placed in position for pouring.

The normal operation of the furnace is as follows:

Ordinary Bessemer pig iron is full blown in a 15-ton Bessemer converter, in from eight to twelve minutes. It is then poured directly from the Bessemer vessel to an electric furnace transfer ladle, and drawn by locomotive to the electric furnace building, a distance of about $\frac{1}{4}$ mile (400 meters), in about five minutes. As a precaution against the possible formation of a skull in the ladle, the Bessemer charge is blown about 1500 lb. (680 kg) of scrap "hotter" than ordinary Bessemer practice.

Immediately the ladle is received at the electric furnace it is picked up by the crane, slightly tilted, and the silicious slag is completely cleaned off by hand-rabbling. The metal is now ready for charging. To do this, the ladle is merely turned over on its trunions and the metal poured into a spout, through which it rushes to the furnace. This operation of cleaning off the slag and charging occupies from five to ten minutes.

The electrodes are lowered and the current turned on.

As the metal is being poured into the furnace, the helpers shovel iron oxide and lime into the furnace through the working doors.

In this way a basic oxidizing slag is produced which serves to remove the phosphorus. In about thirty minutes this slag has served its purpose, and the furnace is tilted slightly forward and the slag removed in from five to ten minutes by hand-rabbling.

The recarburizer is added at this point. On the bare surface of the oxidized metal, lime is quickly added, with sufficient fluor-spar to keep the mass fluid. In about fifteen minutes this lime is melted, and finely divided coke dust is now thrown onto the top of the slag beneath each of the three electrodes.

Under the influence of the arc, calcium carbide is produced in gradually increasing quantities.

As soon as this state of affairs is reached, a neutral if not actually reducing atmosphere has been obtained. From here to the finish there is practically a dead-melt in a reducing atmosphere. The slag at this stage of the process is fluid and highly basic. If a sample should be taken and water added to it, the resultant acetylene gas, from the well-known calcium carbide and water reaction, is of sufficient quantity to light and burn for half a minute.

Tests are now taken to show the condition of the steel. A small cylindrical test piece is poured and forged to a round pancake-shaped object under a steam hammer located at the furnace. If this forged sample shows by its appearance a satisfactory condition of the metal, the bath is tapped. If not, further refining is necessary.

To tap the furnace the electrodes are raised from the bath and the ladle swung by a crane under the pouring spout and the tilting level pulled forward.

The pouring is done through a $1\frac{1}{2}$ -in. (4-cm) nozzle to molds of varying sizes.

It takes an hour and a half to two hours to a heat, according to the grade of steel produced.

What is actually done in the electric furnace at the South works is to take oxidized blown metal of an approximate analysis of

C	S	P	Mn	Si
0.05-0.10	0.035-0.070	0.005	0.05-0.10	0.005-0.015

and produce deoxidized steel low in sulphur and phosphorus and, within reasonable limits, of practically any analysis required by the consumer.

The electric furnace at South Chicago has operated on a greater variety of product than any furnace in the world, and with bewildering intermingling of high-grade alloy steels, high-grade carbon steels and ordinary carbon steel. They have made

ordinary carbon steel rails of a dozen different sections, billets of all sizes and grades, plates of all sizes and grades, structural shapes, castings, small and large, high carbon and low, and forgings of all sizes; of alloy steels they have made nickel, nickel-chrome, chrome, manganese and silicon steels.

They have made a number of heats from cold materials. In several of these they took the worst scrap they could pick up—stove-plate scrap. With this stock an axle heat was made which showed excellent physical tests. Seventy-seven blows from a 1640-lb. (750-kg) hammer falling 43 ft. (13 m) broke the first axle, and 68 similar blows the second.

The main chemical or physical characteristics in electric steel seem to be these:

A comparative freedom from oxidation.

A comparative freedom from segregation.

A higher tensile strength and slightly higher ductility for the same chemical analysis up to about 0.40 carbon, where the difference becomes less apparent.

A steel of greater density than other commercial steels, with the possible exception of crucible.

In conclusion, Mr. Osborne said that the three electric furnaces of the Steel Corporation are the largest in the world that have as yet been put in operation. They have presented many interesting and complex problems, and the manufacturer has encountered occasional troubles. "Although we feel that we are as yet but on the threshold of this method of manufacture, we feel that electric steel is a success and its future assured."

Mr. Osborne's paper brought out considerable discussion. Mr. Osborne stated that the South Chicago furnace was the oldest of the Héroult electric furnaces of the Steel Corporation and that in the newer one in Worcester several improvements have been made; especially in the arrangement of the electrodes. While it takes five minutes in Worcester to change electrodes, it takes half an hour in South Chicago. Other disadvantages at the South Chicago plant are the relatively small space available and the distance of the electric furnace from the Bessemer converter house, which makes it necessary to blow the steel 200° or 300° hotter than ordinary Bessemer metal. This accounts for the fact that the metal comes colder out of the electric furnace than it goes in. They have used all kinds of electrodes; at present they are using 14-in. amorphous carbon electrodes of the National Carbon Company.

In reply to a question by Mr. Hansen, Mr. Osborne stated that the increased tensile strength of the electric steel is due to greater density. The greater density is due to absence of gases. Electric steel, properly made, has segregation practically nil, except right below the pipe.

Mr. Saunders considered it the function of the electric furnace to do only the most difficult work, to supply only the peak of the temperature, and referred to a furnace of the National Carbon Company, which is chiefly heated by gas and only the last 200° or 300° are supplied by electricity.

Mr. Hansen disagreed with respect to the use of electric furnace for peak work only; he considered this as uneconomical, since the overhead charges of the electric plant go on all the time.

Dr. Richards referred to the use of the electric furnace as a dead melter without any refining. Simply by holding the finished steel in an electric furnace, say, for 30 minutes, to let it rest and let the oxides and gases rise and get out, it is possible to improve the quality of the steel considerably.

As in the South Chicago practice the steel goes hotter into the electric furnace than it comes out of it for the local reasons stated above it is evident that the advantage of the electric furnace in this case is not thermal efficiency. This brought up again a discussion on the efficiency of electric furnaces.

Dr. Richards argued that two kinds of efficiency must be distinguished. First, there is the case where the furnace is used as a melting furnace; electricity is then used to raise the temperature. Second, there is the case where the metal is simply kept molten at a materially constant temperature; in this case

the efficiency must be defined differently from the first case. Both cases must be clearly distinguished.

Mr. Langmuir thought that in the second case it was hardly possible to speak of efficiency because the use of this term presupposes that a 100 per cent efficiency is imaginable.

Dr. Lidbury expressed the opinion that there was nothing to be gained at all by speaking of the "thermal efficiency" of an electric furnace, because in order to express it in percents it is necessary to make so many arbitrary assumptions and hypotheses on account of a great many factors which cannot be measured. Instead of speaking of efficiency he preferred a straight statement that so and so many kw-hours are required per ton of metal produced, etc., as such specific statements would give all the information needed.

Dr. Richards thought that the use of the term "efficiency" was proper even in the case where it is simply a question of keeping a furnace charge continually at the same temperature, because one furnace does that with 50 kw per ton of charge and another with 200 kw.

Dr. Lidbury thought that such comparative specific statements as the one just mentioned gave all the needed information without bringing in "efficiency" at all.

Mr. Osborne stated that it was a matter of experience that with 14 practically identical open-hearth furnaces, as at South Chicago, the pounds of coal per ton of output might vary considerably, and that the figure depended essentially on the management. Hence the "thermal efficiency" would be in practice largely a question of management, of the hustling of the attendants, etc.

Electrolytic Furnace Process for Production of Pure Metals.

MR. JOHN WOODS BECKMAN, of Niagara Falls South, Canada, presented a paper in which he expressed the opinion that the fused electrolyte would be the electrolyte of the future. He referred to the production of aluminium from alumina and asked whether it should not be possible to produce all metals in a similar manner from their oxides; but what electrolyte is to be used?

A comparatively little known group of salts are those occasionally occurring in nature, composed of equivalent amounts of calcium oxide and the oxide of any metal less positive than calcium. These salts occur occasionally in nature comparatively pure, as is the case with Scheelite, and can very readily be produced by heating the oxides together in any suitable manner.

There is a great number of these salts possible, and the characteristic feature of them is that they all fuse at about and over 1000° C., the temperature varying according to the metal oxide which calcium oxide is combined with. The boiling point of these salts is very high.

The valuable feature of these salts is that when in a molten condition they carry the current very readily, and are very suitable as molten electrolytes for the production of a great number of metals.

Mr. Beckman stated that he had produced in this way manganese, iron, chromium, and a 50 per cent alloy of vanadium.

To describe the principle of the process Mr. Beckman described the production of iron. Equivalent amounts of Fe_2O_3 and CaO are mixed together and heated in any suitable manner. The salt $\text{CaO} \cdot \text{Fe}_2\text{O}_3$ is formed and fused in a receptacle fitted for electrolytic purposes. Oxide of iron is introduced into this fused bath, and this molten solution is electrolyzed, iron being deposited on the cathode and a lively oxygen development taking place on the anode.

If the electrolyte itself is submitted to the direct current, no noticeable reaction takes place, but the moment iron oxide is added the electrolysis starts, and by adding from time to time more oxide it can be carried on continuously.

The practical features of this method are: First, cost of electrolyte practically negligible, as it is composed of calcium oxide and the metal oxide of the desired metal; second, a great quantity of metal can be produced out of the same electrolyte;

third, in case the electrolyte becomes fouled the loss in discarding the electrolyte is practically negligible; fourth, the flexibility of the process making it possible to produce a great number of metals and their alloys, such as iron, manganese, chromium, zinc, tin, titanium, vanadium, tungsten, tantalum, molybdenum, nickel, cobalt, lead and a number of others more or less rare.

Mr. Beckman finally gave the following list of the theoretical amount of meal deposited per ampere hour, considering only ideal conditions:

	Oxide	Gram per amp. hr.
Aluminium	Al_2O_3	0.3377
Lead	PbO	3.868
Chromium	Cr_2O_3	0.655
Iron	Fe_2O_3	0.606
Manganese	MnO	1.027
Nickel	Ni_2O_3	0.732
Zinc	ZnO	1.220
Titanium	TiO_2	0.445
Vanadium	V_2O_5	0.64

There was considerable discussion of the paper, in which Messrs. Hansen, Bleecker, Tucker, Walker, Richards and Saunders participated. Mr. Hansen and Professor Tucker expressed the opinion that there was no experimental evidence that the metals produced by Mr. Beckman were the result of electrolysis, since on the small scale employed there might have been simple high-temperature reduction by carbon from the graphite crucible.

An Electric Converter Process.

Mr. ALBERT E. GREENE, of the American Electric Smelting & Engineering Company of Chicago, presented a paper on "Electric Steel Processes as Competitors of the Bessemer and the Open Hearth." This is a new development, as heretofore electric steel processes have been used largely for the production of high-grade steel, practically of crucible-steel quality. Mr. Greene urges, however, that there is a distinct possibility

process some authorities give the amount of iron lost in open-hearth slag as 2.5 per cent of the weight of steel made, and the loss of manganese, 0.5 per cent.

It is an interesting fact that much of our iron ore contains the elements manganese and silicon in sufficient quality to meet the specifications of ordinary steel, and moreover, these elements are reduced in the blast furnace and are almost invariably present in the pig iron in sufficient quantity to meet

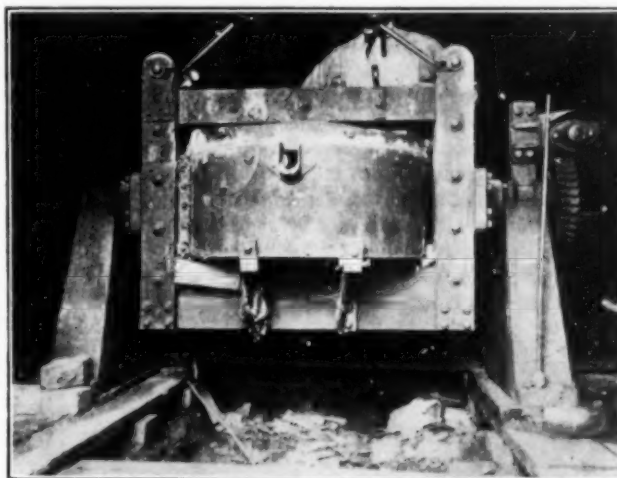


FIG. 2.—ELECTRIC CONVERTER.

requirements without any additions, were it possible to save them in the converter; but during the converter blow the silicon and manganese are practically all eliminated and then these alloying metals are put back again by charging into the steel some expensive alloy additions. It costs to reduce these elements in the blast furnace, and it costs to replace them again after they are oxidized. The value of the manganese so lost is quite important.

The object of Mr. Greene's paper is to point out how the electric furnace in combination with a control of chemical reactions by regulating the gaseous agents, provides a means of producing metal of higher grade and of doing it more efficiently and with far less loss than is possible in Bessemer or in open-hearth furnaces, and to describe a new process which takes advantage of a combined control of temperature and gaseous reagents to accomplish such a saving. The chief advantage of the electric furnace does not consist simply in its ability to produce extremely high temperatures; but rather in the fact that it provides a means of maintaining a charge at any given temperature, thereby enabling one to control the composition of the atmosphere at will.

In this connection Mr. Greene discussed the meaning of the term "neutral," as commonly applied to the atmosphere within furnaces in general, including electric furnaces. "Neutral" means inactive. But the atmosphere, if of proper composition, may react in such a way as to greatly aid a metallurgical process; for instance, the atmosphere in a steel-producing furnace might be reducing toward iron oxide and prevent the steel from oxidizing; or it might be oxidizing toward carbon or phosphorus, and thereby eliminate them. Now, it is a most interesting fact that we can have an atmosphere which is reducing with respect to iron oxide and nevertheless oxidizing toward carbon or toward phosphorus. For this reason it seems that the term "neutral" and also the term "non-oxidizing" is very indefinite, where there are different elements present, unless it is stated with respect to what the atmosphere is neutral or non-oxidizing.

In view of the fact that it is possible to have an atmosphere which simultaneously is reducing toward iron oxide and oxidizing toward carbon, the author sketches the following theoretical process for oxidizing carbon out of iron without oxidizing the metal itself. If molten pig iron be placed in a closed crucible,



FIG. 1.—ELECTRIC CONVERTER.

for an electric-furnace process for ordinary grades of steel in competition with converter and open-hearth on account of the unavoidable great losses of metal in the two latter processes.

In the conversion of pig iron into steel by the Bessemer process there is a loss, which approximates 4 or 4.5 per cent of the total weight of the charge in iron and practically all of the manganese, which latter approximates $\frac{1}{2}$ per cent, and making a total unavoidable loss of about 5 per cent of the weight of the charge in these two metals. For the open-hearth

made of magnesite for instance, and kept at a uniform high temperature, and the space above the iron in the closed crucible filled with carbon dioxide gas, the gas and iron will react and finally come to a state of equilibrium. The reaction might be represented as follows: $\text{CO}_2 + \text{Fe} = \text{FeO} + \text{CO}$. Under the equilibrium conditions which would be reached the ratio of the amounts of the two gases present would have a given value for the particular temperature.

If we then replace the mixture of these two gases by another mixture containing relatively more carbon monoxide and less carbon dioxide than the equilibrium mixture, and allow this new mixture to react with the iron and the iron oxide, some of the iron oxide would be reduced and the CO_2 component of the gas increased. This replacement could be made continuous by successive introductions of the new mixture. In this way reduction of iron oxide could be carried practically to completion, and moreover, this could be done by means of a gas containing an oxidizing agent for carbon.

This was the theory on which the American Electric Smelting & Engineering Company started in its experiments several years ago to develop a practical process for converting pig iron into

The process consists of providing a bath of molten low phosphorus pig iron containing, for example, the usual proportion of manganese, silicon and carbon. The charge preferably contains sufficient manganese and silicon to slightly more than meet the specification for the particular steel to be made. The temperature of the bath is raised to something over 1425°C ., and, while it is maintained by the electric heat, a gaseous mixture containing carbon monoxide and carbon dioxide is blown into the metal in much the same way as air is blown into a Trowen converter.

This mixture may contain 12 to 18 per cent of CO_2 and 5 per cent or more of CO .

The rate of elimination is a little slower than with the Bessemer process for the same rate of blowing. A well-operated, side-blown converter requires from 25 to 35 minutes to make a blow, using about 1500 cu. ft. of gas per minute per ton of metal. In this small induction furnace, using about 50 cu. ft. of gas per minute per 200 lbs., or about one-third the rate of blowing in the side-blown Bessemer vessel just referred to, the carbon can be eliminated in something more than an hour and one-half, depending on how much carbon there is at the start. Thus, with only one-third as much gas blown per minute per unit weight of metal, the time is a little more than three times as long as for a similarly blown vessel using air. By increasing the rate of blowing the time can be very greatly cut down.

In this small furnace pig iron can be converted into steel with as small a loss of iron and manganese and silicon as 2.5 per cent, including losses of metal in charging and spills in handling the steel.

The most convincing evidence in Mr. Greene's opinion, that oxidation does not take place in this process may be found in connection with the loss of manganese. In converting a 13.4 per cent spiegel (containing 13.4 per cent manganese) into manganese steel they have done this without any additions of any kind and have produced a steel containing over 12.5 per cent manganese, and this was without the use of a slag to prevent vaporization. The carbon was reduced from over 4 per cent to 1.20 per cent.

In later tests, using a lime slag, the vaporization loss has been further diminished.

It is well known that the high percentage of carbon present in commercial ferro-manganese makes it practically impossible to obtain as much as 12 to 14 per cent of manganese in manganese steel without raising the carbon content above 0.9 or 1 per cent. No great difficulty is met with in producing very low-carbon manganese steel by the electric converter process, and the properties of low-carbon manganese steel are very interesting.

Mr. Greene finally considered the application of the process to the removal of phosphorus and sulphur and to the production of a high-grade steel from low-grade pig iron in one continuous process.

Mr. Greene states that in the electric converter he can oxidize phosphorus out of iron and hold it out by means of lime and do this with practically no oxidation of iron or manganese. He has done this at pig iron temperatures below 1350°C . without oxidizing carbon, and he has done it at high temperatures, above 1500° and up to 1900° after carbon has been oxidized. And beside these facts he found that the sulphur can be taken up and held in this same slag that holds the phosphorus, which action he attributes to the absence of oxide of iron in the slag.

He has converted a low-grade pig iron into a high-quality steel in one continuous operation in this way, taking out the carbon without oxidation of iron and manganese and then, with a lime slag on top of the metal, by continuing the blow of the gaseous mixture, the phosphorus has been oxidized and eliminated. The phosphorus was found combined with the lime as calcium-phosphate and practically all the sulphur was found in the slag as calcium-sulphide.

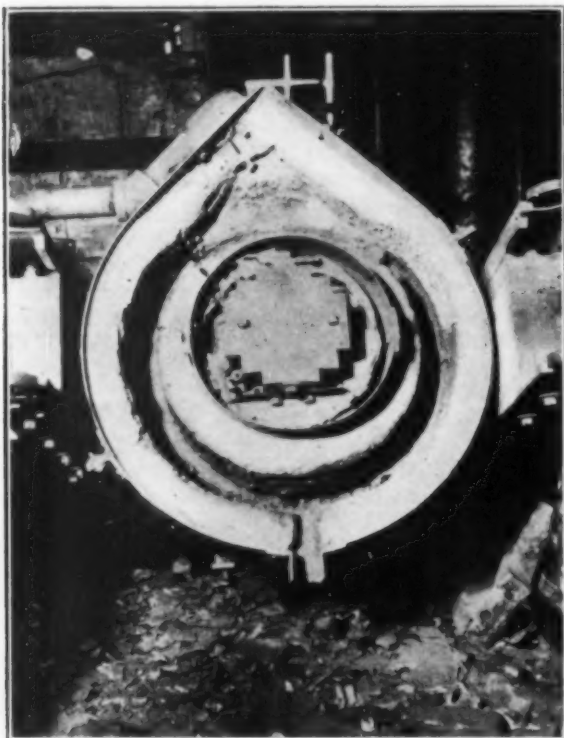


FIG. 3.—ELECTRIC INDUCTION-HEATED CONVERTER WITH COVER REMOVED.

steel and refining it without oxidizing the iron and other valuable constituent metals.

In the preliminary experiments it was found that there was a wide range of composition of mixtures of CO_2 and CO gases suitable to prevent oxidation.

It was found that producer gas might easily be made to serve the purpose, and that a producer gas containing as little as 4 per cent of carbon monoxide and as much as 15 per cent of carbon dioxide would, when blown into molten pig iron at a temperature of about 1450°C ., eliminate the carbon with practically no oxidation of iron, manganese or silicon.

After the preliminary experiments which were made in small electrically heated crucibles, the process was carried out in an induction-heated vessel of 300 pounds' capacity.

This furnace had an enlarged portion at the back forming a pot, and tuyeres were put into this part in much the same way as they are put in a Trowen converter.

He has had such results as follows:

Analysis of charge.....	Phosphorus, .76%	Sulphur, .113%
Analysis after blow.....	". .026	". .040
and also		
Analysis of charge.....	Phosphorus, .094	Sulphur, .040
Analysis after blow.....	". .008	". .017

He has carried out such a conversion of molten pig iron into refined molten steel as just outlined in less than thirty minutes, which indicates that the reaction takes place quite rapidly and that the problem of installing the process in large vessels of ten or more tons capacity is a mechanical one of getting the gas into the metal.

Mr. Greene then compared the electric converter process with the Bessemer converter, the open-hearth and the Bessemer converter electric furnace combination processes, and finally said a few words on the type of electric furnace used for his converter process. The induction furnace has shown important advantages. In the operation of this process in large induction-heated furnaces he believes that less than 30 kilowatt-hours per ton of steel will be required.

The substitution of a gas containing carbon monoxide and carbon dioxide for air is believed not to involve as great a change in present methods as at first it may appear to do. Such gas as is needed to carry out this process is available from cupolas or blast furnaces or may be made in a very simple gas producer. Blast furnace gas is preferably modified by mixture with stack gas, since the percentages of carbon monoxide in blast furnace gas is usually much higher than required. The process itself, at least in so far as the elimination of carbon is concerned, is a gas producer process, the off-coming gas being richer in CO and lower in CO₂ than when blown into the metal; and this fact opens the possibility of using the gas over and over by burning a part of it to maintain the desired composition.

The paper was briefly discussed by Dr. Richards and Mr. Hibbert.

The Pinch Phenomenon Employed for Electric Furnace Design.

A paper by Mr. CARL HERING, of Philadelphia, Pa., describes "a new type of electric furnace" in which use is made of the "pinch phenomenon."

Let the circle, Fig. 1, represent the cross-section of a cylindrical conductor; the electromagnetic forces which constitute the pinch phenomenon tend to act radially as shown by the arrows. If now the conductor be made to be a vertical column of liquid as, for instance, the part marked "resistor" in Fig. 2, consisting of a hole in a non-conducting material closed at the bottom by the electrode and filled with the liquid, then these forces will act horizontally and perpendicularly to the axis along the whole length. They create a suction near the periphery and a pressure at the center.

Moreover, by hydraulic action these radial forces in turn produce corresponding longitudinal forces at the center and at the periphery, and as these axial or vertical forces cannot expend themselves at the bottom they do so at the top, thereby producing a veritable fountain, as shown in Fig. 2, the liquid flowing up in the center and down at the periphery about as shown by the arrows; moreover, the direction of this hydraulic flow is independent of the direction of the electric current, hence is the same for direct or alternating currents.

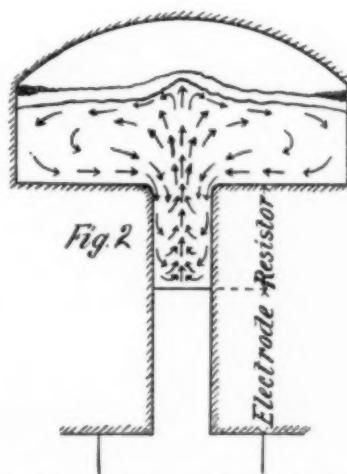
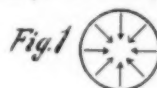
This new phenomenon, which was colloquially named the "squirting phenomenon," is made by Mr. Hering the basis of a liquid resistor furnace. If such a column is made the resistor in which the heat is generated by passing the current through it by means of an electrode at the bottom, the heated liquid will be rapidly expelled and forced to the top against the blanket of slag, while the cooler liquid at the bottom will be sucked down into the hole near the circumference to be in turn heated and immediately expelled with considerable force. With energetic circulation through the resistors the fatal objections to the use of liquid resistors could be overcome.

In practice one would naturally use two holes, one for each

electrode, as that reduces the depth of the hole to one-half. The proportions of the hole, that is, the ratio of the section to the length, are, of course, determined by the resistivity of the material, the amount of heat to be generated and the relation of the volts to the amperes; the actual dimensions are therefore still a matter of choice. The ejecting force, or "squirting force," increases with the square of the current and diminishes as the cross-section increases. It will be seen therefore that there is very fortunately some choice left as to the dimensions of these "flowing resistors."

In most materials there is apparently a very rapid rise of resistivity with the temperature, which is very favorable to the proportions of such resistors, as is also the apparently very rapid increase of the specific heat of iron at the higher temperatures.

The advantages of a furnace based on this principle are stated by Mr. Hering as follows: It is ideally simple and cheap, consisting merely of a crucible or hearth with two suitable holes in the bottom plugged with the electrodes. The heat is generated in the material itself, which is just where it is wanted; moreover, it is generated in the most rational place, namely, at the bottom and not on the top surface; it is conveyed and distributed mechanically, so to speak, throughout the melted mass, and this conveyance of heat is immensely more rapid than it would be by mere conduction or by the slow flow due to differences of density; hence a charge is treated and finished rapidly, whereby the output of the furnace per day is increased and the losses of heat per ton are proportionately reduced. As



FIGS. 1 AND 2.—PINCH AND SQUIRT PHENOMENA.

far as is known now there is no temperature limit except that of the failure of the refractory lining, as the pinch effect can no longer limit the temperature.

This very active agitation and circulation of the liquid mix the product rapidly with any of the refining ingredients which may be added and tend to make the product very homogeneous. Every particle of the liquid is in turn, and repeatedly, brought to the surface, where mechanically suspended impurities and gas bubbles are expelled and forced into the slag and where the metal is exposed to the chemical action of the slag. The temperature at the surface of contact of metal and slag, on which temperature the slag action depends, is maintained better when the heat flows up naturally from the hot metal to the cooler slag than when it is forced to flow down unnaturally from the hotter slag to the cooler metal.

Other advantages besides this lie in the fact that the electrodes are very cheap, are not consumed, and as they may be made of

metal they are far more economical in energy loss than carbon or graphite would be. No moving and adjusting of the electrodes are required. The interior of the furnace may be made as small as the quantity of material to be held requires, hence the thermal efficiency of the walls of such a furnace could be made to reach the practical maximum of all types of furnaces. Moreover, as the heat is rapidly distributed mechanically throughout the mass, the maximum temperature need be no higher than that required for the desired metallurgical or chemical action, hence the heat losses, which increase rapidly with the temperature, are correspondingly reduced; in this there is a great advantage over arc furnaces, in which the temperature is necessarily that of the vapor of carbon, hence immensely higher than what is needed.

The regulation is simple, rapid and in fact ideal. When the electrode is made of the same diameter and material as the resistor the furnace tends to become self-regulating as to temperature. When, for instance, the temperature becomes higher the electrode automatically becomes longer and the resistor therefore shorter, whereby less heat will be generated and the reverse when the temperature becomes lower. The place where the electrode ends and the resistor begins is, of course, that section across which no heat flows; the heat generated below this section flows out to the terminal and that generated above it flows into the furnace; it is this plane that automatically moves up or down.

The hottest liquid is that in the center of the resistors and is therefore not in direct contact with the refractory lining.

The friction of liquid against liquid, in the interior of the conductor, is far less than might be supposed, provided the liquid is in a very fluid state. The rapid flow is not along the walls of the hole, but in the center where it causes no wear.

The counter e.m.f. which must necessarily be generated by the movement produced is an advantage as it shortens the resistor.

By using a bath of some suitable metal in the bottom of the furnaces as the prime receiver of the heat, the furnace is adapted to be used to melt non-conductors like glass, or to heat granular ores, reduce and volatilize such metals as zinc and arsenic from their ores, etc. By dissolving carbon in the iron in one part of a bath and the oxide in another part, iron can be reduced from its ores and the CO gas produced can be burned to preheat the ore, whereby the total energy of the carbon may be utilized.

The power factor can, of course, be made very high, probably practical unity, and, unlike in the induction furnace, the frequency need not be abnormally low.

When badly proportioned the columns are apt to pinch off, causing rapid "makes and breaks"; this so greatly reduces the amount of heat which can be generated that there is danger of freezing. Such repeated breaking of the circuit should by all means be avoided. Several times a charge was left to freeze in the furnace over night and yet was readily started the next day from the cold state, thus showing that the resistors do not part in shrinking.

The larger the furnace the better and the less will be the difficulties, because the resistors then become shorter and thicker. There are, of course, many modifications which at once suggest themselves which will be tried in due course. It would be quite simple, for instance, to add gaseous fuel heat, or the heat of an arc, in the upper part; or to add the electrical parts to existing open-hearth or other furnaces and use the electric heat only for the final treatment.

The transformer is best attached directly to the bottom or side of the furnace, as the furnace currents are of course of low voltage, hence large in amperes. The flexible connections to a tilting furnace then consist merely of the two thin primary wires. The furnace is readily adapted to three-phase currents; the only change is that there will be three holes and electrodes instead of two. This is an advantage because for the same current in each electrode it shortens the resistors by one-third.

A two-phase current may be readily transformed into one of three phases by means of a Scott transformer.

Under all conditions there should always be reached a stable state of temperature in the resistors, at which the heat generated in them is equal to that carried out of them mechanically; the best conditions must be determined by practice; fortunately there is a considerable range of latitude in the proportions which could be chosen.

Mr. Hering's paper is concluded by a list of some of the objectionable, troublesome or undesirable features of arc, induction and simple resistance furnaces with liquid resistors, and the claim is made that they would all be avoided entirely or at least lessened in his present type of furnace.

Mr. Hering's paper was discussed by Messrs. Hibbert, Clamer, Saunders, Richards, Hitchcock, Kemery, and Queneau. Mr. Hering stated that the tubes in which the squirt phenomenon is produced are made of alundum and Mr. Clamer stated that the wear and tear of the tubes is practically nil.

Iowa and Maine for Electrochemical Industries.

A paper by Mr. FRANK P. H. KNIGHT discussed the advantages of Keokuk, Ia., for electrochemical industries, due to the water-power development now going on. The initial installation will be 120,000 hp, which it is expected will be completed in two and one-half years. This will be increased later to 200,000 hp. The author also gave data on commercial advantages, natural resources, transportation facilities by rail and water, and factory sites.

A paper by Mr. C. VEY HOLMAN, State geologist of Maine, discussed the advantages of Maine for electrochemical industries. He pointed out the geographical advantages and the possibilities of water-power developments; he estimated that 2,500,000 hp would be available. The author concluded with reference to the iron ores and other mineral resources of Maine.

After a vote of thanks to all who had made the convention successful, the meeting adjourned.

The next convention will be held in autumn at Toronto, Ontario, Canada.

In the following we give a complete alphabetical list of the names of members and guests in the last printed registry list. Where no city is stated, New York City is meant.

P. O. Abbe, C. E. Acker, Ossining, N. Y.; A. Allan, Jr.; Mr. and Mrs. G. Alleman, Swarthmore, Pa.; R. Amberg, Pittsburgh, Pa.; F. Andrews, Perth Amboy, N. J.; J. C. Andrews, Ithaca, N. Y.; W. C. Arsem, Schenectady, N. Y.; D. K. Bachofner, Irvington, N. J.; H. R. Badger, Detroit, Mich.; Dr. and Mrs. L. H. Backland, Yonkers, N. Y.; T. F. Bailey, Alliance, Ohio; J. T. Baker, Phillipsburg, N. J.; W. D. Bancroft, Ithaca, N. Y.; J. M. Barnett, A. W. Barron, Cleveland, Ohio; Chas. Baskerville; E. A. Beck; F. Becker, Niagara Falls, N. Y.; E. H. Bedell, Newark, N. J.; J. W. Belkman, Niagara Falls, Ont.; P. McN. Bennie, Niagara Falls, N. Y.; S. D. Benoliel, Philadelphia, Pa.; D. D. Berolzheimer; Mr. and Mrs. E. R. Berry, Walden, Mass.; Mr. and Mrs. W. F. Bleecker, Denver, Colo.; P. A. Boeck, Worcester, Mass.; G. Boericke, Primus, Pa.; M. T. Bogart; W. Bowman; C. S. Bradley; A. A. Brennan; Miss C. P. Briggs, Brooklyn, N. Y.; C. P. Brown, Smithsburg, Md.; J. W. Brown, Cleveland, Ohio; C. A. Campbell, Boston, Mass.; C. R. Carey, Philadelphia, Pa.; C. F. Carrier, Jr., Seward, N. J.; H. R. Carveth, Niagara Falls, N. Y.; H. Casselberry, Altoona, Pa.; J. Casselberry, Altoona, Pa.; C. C. Cito, Irvington, N. J.; G. Clamer, Philadelphia, Pa.; J. C. Clancy; Mr. and Mrs. F. O. Clements, Dayton, Ohio; Mr. and Mrs. W. R. Clymer, Cleveland, Ohio; Mr. and Mrs. J. Coates, Coatesville, Pa.; F. P. Coffin, Schenectady, N. Y.; B. Cohen, C. C. N. Y.; S. Cohn; H. B. Cohn; E. A. Colby, Newark, N. J.; A. M. Comey, Chester, Pa.; E. A. Congdon; E. B. Conklin, Ossining, N. Y.; H. R. Connell, Pittsburgh, Pa.; J. C. Cothran, Harrison, N. J.; Mr. and Mrs. W. A. Cowan, Brooklyn, N. Y.; Mr. and Mrs. A. H. Cowles, Seward, N. J.; F. Crabtree, Pittsburgh, Pa.; F. N. Crawford, Middletown, Conn.; B. O. Crites, Cleveland, Ohio; M. A. Daniels; P. Darkicos, E. Orange, N. J.; T. Darlington; Mr. and Mrs. E. A. Deeds, Dayton, Ohio; P. K. Devers, Jr.; W. Dickinson; C. Dill, Perth Amboy, N. J.; C. A. Doremus; W. Dreyfus; G. Drobegg; E. Durant; H. F. Durham; A. S. Dwight; C. H. Eldridge, Newark, N. J.; J. W. Elms, Haskell, N. J.; C. E. Evans, Philadelphia, Pa.; J. W. Evans; W. E. Fairhurst, S. Bethlehem, Pa.; R. W. Faust, Bethlehem, Pa.; K. Fenning; B. G. Fernberg; H. M. Fernberger, Newark, N. J.; A. Finck, Cleveland, Ohio; Dr. and Mrs. C. Fink, Harrison, N. J.; C. Fitz Gerald; F. A. J. Fitz Gerald, Niagara Falls, N. Y.; K. G. Frank; Milton W. Franklin, Schenectady, N. Y.; T. Fukin; Richard H. Gaines; F. W. Garen; Miss Gibbs, Wyandotte, Mich.; H. E. Gibbs, Wyandotte, Mich.; J. Goldbaum, Philadelphia, Pa.; F. X. Govers; S. H. Graham, Newark, N. J.; A. E. Greene, Chicago, Ill.; J. Griffin, Bethlehem, Pa.; H. B. Haigh; W. A. Hamor; J. H. Hall, High Bridge, N. J.; A. M. Hamblet, Rumford, Me.; C. Hambuechen, Madison, Wis.; W. J. Hammer; N. V. Hansell; C. A. Hansen, Schenectady, N. Y.; L. O. Hart, Hoboken, N. J.; D. S. Hartshorn; W. H. Hendricks, Palmerton, Pa.; W. A. Hendryx; C. I. B. Hennig, Haskell, N. J.; C. Hering, Philadelphia, Pa.; P. L. T. Heroult; H. Hess, Philadelphia, Pa.; B. C. Hesse; R. Hewitt, Ardsley-on-Hudson; H. D. Hibbard, Plainfield, N. J.; E. F. Hicks, Philadelphia, Pa.; A. Higgins, Worcester, Mass.; A. E. Hikelman, Tremont, Pa.; Mr. and Mrs. H. H. Hitchcock, Tarentum, Pa.; G. B. Hogaboona, Newark, N. J.; J. F. D. Hoge; W. E. Holland, E. Orange, N. J.; F. Holmgren, Sweden; A. H. Hooker, Niagara Falls, N. Y.; H. Howard,

Boston, Mass.; Mr. and Mrs. H. A. Horner, Philadelphia, Pa.; G. A. Hulett, Princeton, N. J.; M. A. Hunter, Troy, N. Y.; W. R. Ingalls; Mr. and Mrs. A. von Isakovics, Monticello, N. Y.; E. B. Jewett, Clarksburg, W. Va.; Mrs. R. A. A. Johnston, Ottawa, Ont.; W. M. Johnson, Hartford, Conn.; Mrs. A. F. Joyce, Boston, Mass.; Mr. and Mrs. C. M. Joyce, Arlington, N. J.; R. Kunn; C. P. Karr, Plainfield, N. J.; N. S. Keith, Philadelphia, Pa.; J. T. Kelly, Philadelphia, Pa.; P. Kemery, Pittsburg, Pa.; E. F. Kern; F. L. Koethen, Bloomfield, N. J.; M. M. Kohn; L. Kristeller; L. J. Krom; Miss N. Laib, Philadelphia, Pa.; Dr. and Mrs. G. F. Kunz; I. Langmuir, Schenectady, N. Y.; J. Langton; E. Leavitt, Brooklyn, N. Y.; C. A. Le Boutillier, High Bridge, N. J.; W. S. Lenk, Toledo, Ohio; F. A. Liddbury, Niagara Falls, N. Y.; D. M. Liddell, Elizabeth, N. J.; C. Lindsay, Schenectady, N. Y.; M. Loeb; M. L. Loeb; E. G. Love; A. F. Lucas, Washington, D. C.; H. J. Lucke; P. Luhr, Newark, N. J.; T. L. B. Lyster, Niagara Falls, N. Y.; Wm. Main; C. W. Marsh; G. H. Marshall; E. J. K. Mason; J. H. Mathews, Madison, Wis.; Irving C. Matthews, Harrison, N. J.; P. H. Mayer, Mt. Vernon, N. Y.; G. W. Maynard; F. J. Maywald; A. S. McAllister; J. H. McCreary; C. F. McKenna; C. Mendeleff, Mauver, N. J.; F. C. Meucke, Philadelphia, Pa.; L. B. Miller, Newark, N. J.; C. P. Monto, Cleveland, Ohio; H. R. Moody; S. R. Morey; F. D. Morgan, Mt. Vernon, N. Y.; J. F. Morgan, Bronxville, N. Y.; Mr. and Mrs. F. D. Morgans, Mt. Vernon, N. Y.; G. D. Morgans, Bronxville, N. Y.; C. H. Moritz, Niagara Falls, N. Y.; C. W. Moulton, Poughkeepsie, N. Y.; J. M. Muir; A. Neisch; H. B. North, New Brunswick, N. J.; C. H. Ohlweiler, Altoona, Pa.; R. S. Orr, Pittsburgh, Pa.; C. G. Osborne, Chicago, Ill.; J. A. Oswald, Dayton, Ohio; G. S. Page, Pittsburg, Pa.; J. H. Parker, Reading, Pa.; L. A. Parsons, Gettysburg, Pa.; H. E. Patten, Washington, D. C.; F. A. Pattison; T. R. Patton, Philadelphia, Pa.; A. M. Peck, Port Chester, N. Y.; J. C. Pennie; G. A. Perley; P. A. Pfeiffer, Hoboken, N. J.; W. J. Plews, Montreal, Can.; H. A. Plusch, Perth Amboy, N. J.; B. Popper; W. S. Potter; W. B. Pritz, Cleveland, Ohio; J. Probst, Paterson, N. J.; A. L. Queneau, Philadelphia, Pa.; T. S. Quinn, Brooklyn, N. Y.; A. W. Ramage, Buffalo, N. Y.; R. W. Rebenklaus; Dr. and Mrs. J. W. Richards, South Bethlehem, Pa.; Miss W. Richards, So. Bethlehem, Pa.; H. K. Richardson, State College, Pa.; H. S. Riederer; G. Rigg, Palmerton, Pa.; M. M. Riglander; C. D. Robb; A. G. Rodgers, Niagara Falls, N. Y.; E. F. Roebert; A. Rogers, Brooklyn, N. Y.; F. W. Roller; E. Romanelli, State College, Pa.; L. G. Rowland, Summit, N. J.; D. B. Rushmore, Schenectady, N. Y.; Wm. T. Rynard; A. V. Salmon, C. C. N. Y.; P. G. Salom, Philadelphia, Pa.; G. W. Sargent, Pittsburg, Pa.; L. E. Saunders, Niagara Falls, N. Y.; M. Schaak, Brooklyn, N. Y.; L. B. Schleuder; L. Schlichtung; C. A. Schwarzerberg, Pittsburg, Pa.; W. S. Schneider; F. F. Schuetz; R. C. Schwarz, Rochester, N. Y.; C. F. Scott, Pittsburg, Pa.; W. K. Scott, State College, Pa.; Mr. and Mrs. J. A. Seede, Schenectady, N. Y.; Clayton H. Sharp; H. F. Sill, Pittsburg, Pa.; S. Skowronski, Perth Amboy, N. J.; W. M. Slater, Washington, D. C.; R. Slater, Jersey City, N. J.; A. Smith, Niagara Falls, N. Y.; A. S. Smith, E. Orange, N. J.; A. W. Smith, Cleveland, Ohio; D. Smith, Montclair, N. J.; E. S. Smith, Niagara Falls, N. Y.; H. H. Smith, Belleville, N. J.; J. G. Smull, Palmerton, Pa.; R. C. Snowden, Ossining, N. Y.; J. L. K. Snyder, Cleveland, Ohio; W. L. Spalding, Buffalo, N. Y.; Mr. and Mrs. E. A. Sperry, Brooklyn, N. Y.; E. G. Spillsbury, N. Statham, Yonkers, N. Y.; S. R. Steinhart; Mr. and Mrs. K. R. Sternberg, Springfield, Mass.; F. E. Stoller, Cleveland, Ohio; G. C. Stone; J. S. Stone, Boston, Mass.; J. A. Stremel, Brooklyn, N. Y.; A. H. Strong; F. L. Summers, Altoona, Pa.; J. Sunlover, Newark, N. J.; M. A. Swenarton; T. Taistia, Hoboken, N. J.; J. Takamine; A. O. Tate, Toronto, Can.; Miss C. Taylor, Penn Yan, N. Y.; E. C. Taylor; Mr. and Mrs. E. R. Taylor, Pen Yan, N. Y.; F. D. Taylor, State College, Pa.; J. E. Teeple; C. J. Thatcher; V. J. Thrane, Niagara Falls, N. Y.; H. Thurston, Arlington, N. J.; C. B. Thwing, Philadelphia, Pa.; Mr. and Mrs. M. Toth; S. A. Tucker; R. H. Vail; W. Valentine, Waterbury, Conn.; Mrs. E. W. Vivian; C. H. Vom Baur; L. A. Voorhees, New Brunswick, N. J.; L. D. Vorce, Detroit, Mich.; M. Waddell; Leonard Waldo; Wm. H. Walker, Boston, Mass.; T. D. Waring, Perth Amboy, N. J.; F. S. Wayne; M. G. Weber, Perth Amboy, N. J.; C. A. Weeks, Philadelphia, Pa.; C. Y. Wen; L. Wernstein; Mr. and Mrs. D. Wesson, Montclair, N. J.; Miss M. O. Wesson, Montclair, N. J.; E. Weston, Newark, N. J.; M. C. Whitaker; E. H. Whitlock, Cleveland, Ohio; W. R. Whitney, Schenectady, N. Y.; D. L. Williams; A. M. Williamson, Niagara Falls, N. Y.; E. J. Wolf, Brooklyn, N. Y.; K. Wooyenaka; B. G. Worth; D. K. Wright, Newark, N. J.; M. A. Yunk, S. Orange, N. J.; Fr. Zimmermann, Newark, N. J.

SYNOPSIS.

Gold and Silver.

Amalgamation Following Tube Milling.—It has been the generally accepted practice in South Africa that amalgamating plates in a tube mill plant should shake, as it was considered that the pulp was too concentrated to allow the gold particles to come in contact with the amalgamated surfaces of the plates. In the *Journal of the Chemical, Metallurgical and Mining Society of South Africa*, for January, 1911, Mr. W. R. DOWLING gives some results obtained by stationary plates, showing that they are quite as efficient as the shaking plates.

The experimental work was carried on at the joint plant of the Knights Deep and Simmer East mines. Fifteen plates, each 10 ft. 5 in. long by 4 ft. 7 in. wide, of a three-tube mill plant were stopped shaking, and the fall of the plates increased from 10 to 18 per cent. Under these conditions amalgamation was most satisfactory. For the two months preceding the use of stationary plates the extraction by tube mills was 21.81 per cent of the screen assay value and 34.04 per cent of the tailing value. For the two months succeeding the extraction was 22.94 per cent of the screen assay and 34.02 per cent of the tailing assay.

With a view to reducing the number of plates if possible, it was decided to try a concentrating scheme. Two small

cones and two stationary tables were erected. It was found that the gold released from the sand by tube milling could be concentrated in the underflow of the cones, and that the underflow with some diluting overflow could be handled by two plates. To test this scheme five and two plates took the pulp from one tube mill on alternate days. The result was a difference of 1.2 oz. of amalgam per day in favor of the two plates. After these results the entire plant was put on a basis of two plates per tube mill, and has been operating thus for some time with good results.

In adopting two instead of five plates it is important that the water ratio should be kept low, and it has been found that a moisture of 55 to 57 per cent, or a ratio of solid to liquid of about 1 to 1.27, is the irreducible minimum. Reduced to its simplest form amalgamation simply means bringing the amalgamable gold into contact with the amalgamated surface, and it is apparently accomplished by this arrangement.

Fine Grinding.—The all-sliming or one-product method of cyaniding gold and silver ores has been the subject of more or less varied criticism for some time. The latest and one of the most ardent champions of the system is Mr. H. S. DENNY, who contributes his views to the *Mining Magazine* (London) for March, 1911. Mr. Denny's wide experience in South Africa and Mexico will earn for him a respectful hearing.

Granting that in certain unusual cases the additional outlay for grinding machinery and operating cost will offset any advantages gained by fine grinding, Mr. Denny states most emphatically that as a generalization this belief is wrong. The most pertinent questions on the fine grinding process are its limiting factors and its efficiency. The former are involved in a comparison between the added cost of each extra unit of fine grinding and the added extraction, and are not easily determined. The author finds hope, however, in the recent work by Stadler on the efficiency of grinding machines, and believes that we may yet find a method of computing with some degree of accuracy the all-important figure of cost. As regards the added extraction, there is no doubt that if care is taken this point can be determined.

Discussing the economic considerations, the author assumes the treatment of a silicious ore containing 5 per cent pyritic material. Assume that this be ground to 60-mesh, and that 90 per cent of the pyritic content can be concentrated, carrying 70 per cent of the gold. If the ore assays 0.4 oz. per ton we have after concentration: 4.5 tons of concentrate carrying 28 oz., or 6.22 oz. per ton; 95.5 tons of pulp carrying 12 oz., or 0.125 oz. per ton.

If the pulp were then classified we probably would have, say, 65.5 tons of sand, assaying 0.15 oz. per ton, and 30 tons of slime, carrying 0.0725 oz. per ton.

Now, assuming that an extraction of 80 per cent could be made on each of the above products (concentrate and pulp) by agitating and pressing and without further grinding, the question naturally would arise as to application of finer grinding. It is quite clear that the concentrate is the portion demanding attention. An 80 per cent extraction of the 6.22 oz. would leave a residue of 1.24 oz., whereas an 80 per cent extraction on the original ore (80 per cent of 0.4 oz.) would leave a residue of only 0.08 oz., and it would at once seem possible to materially reduce that by a proper handling of the concentrated portion.

Fine grinding would be suggested as the remedy and might be accomplished as follows:

Regrinding all the pulp from the crushing plant that is coarser than 200 mesh.

Regrinding a hydraulically classified portion of the pulp.

Regrinding a carefully concentrated portion of the pulp.

Assuming that one of these methods was followed and that the extraction would be increased from 80 to 94 per cent, we would find that our concentrate is the portion yielding the greatest increase extraction, and is, therefore, the part to be

considered most carefully. The question would arise whether it might not be best to get a very clean concentrate and regrind that portion only. The main points in connection with this are:

What is the cost per ton of regrinding from 60 to 200 mesh?

If the sand is not reground would it be necessary to have a separate treatment plant for it, or could it be mixed with the concentrate?

If 50 per cent of the valuable content of the ore could be extracted by amalgamation, would that step be advisable, even though the ultimate recovery would not be increased?

As the concentrate contains the bulk of the value, would it not be well to make some provision for regrinding this product so as to insure reduction to absolute impalpability. Could this be done, and how?

Answering these questions seriatim, the author believes that:

The cost of regrinding from 60 to 200 mesh will not be far from the average figure of 75 cents per ton, although varying conditions may change this.

It would not be wise to try to treat the unground sand and the reground concentrates together. In filter pressing the mixture of coarse and fine would cause trouble. While it would be necessary to have separate treatment plants for sand and concentrate, the sand need not be ground so fine as the concentrate. A plant designed to handle and treat one product only would be much more simple in design, less costly in capital outlay, and cheaper to work than a plant consisting of three departments for as many products.

There is nothing to be gained by a recovery of 50 per cent by amalgamation, because the operation costs something and involves some loss, and because it is too easy to steal gold in amalgam form. The extra consumption of cyanide and zinc would be almost inappreciable if all the gold were recovered in the cyanide solution.

If a clean concentrate can be made there is little doubt that it would be advisable to recover it and grind it to impalpable pulp, which is possible in several ways.

The author quotes from a paper of A. Grothe presented before the Mexican Institute of Mining and Metallurgy, in which Mr. Grothe shows a flow sheet embodying the idea of regrinding concentrate and coarse sand in tube mills, keeping the concentrate in the circuit of tables and tube mill until it is ground fine enough to pass off from the tables with the slime.

The author concludes as follows: The day of the percolation method of treatment for sand and the decantation system for the treatment of slime has gone, except in special cases, and it is only due to the persistence of some of the metallurgical fraternity who have been wedded to these ideas that they are to-day included so freely in the treatment of simple gold ores. There can be no logical argument opposed to the principles of the one-product treatment now becoming almost universal, and the only points remaining for settlement are the methods and devices to be adopted in fine grinding, and the degree to which this principle is to be pushed in order to gain the best results.

Modern practice has so emphatically taken up the circulation of cyanide solution throughout the entire plant, followed by fine grinding and filter pressing, and the results have so abundantly demonstrated the value of this practice that there can no longer be any discussion as to its merits. The author predicts that the tendency in the future will be to crush in stages, classify, grind in stages, agitate and filter press on the one-product principle. He believes that the upshot will be cheaper plants, lower working costs and improved extractions.

Combination Treatment of Silver Ores.—As an example of the combination concentration-cyanide treatment of a Mexican silver ore, V. B. SHERROD contributes an experience to the *Mexican Mining Journal* for April, 1911. Before the present system of treatment was adopted a great deal of unsuccessful experimental work was done in an effort to dispense entirely with concentration. Extraction was fair but consumption was

prohibitive. A thorough concentration was possible and successful metallurgically, but the grade of the concentrate was so low that marketing costs would have been excessive.

Finally a series of experiments conducted for another purpose showed how a combination could be effected, whereby the grade of the concentrate would be high, and the consumption of chemicals in cyanidation would not be much higher than when concentration was thorough. The following screen analysis of the lip sample from a battery crushing through 4-mesh screen illustrates the possibilities of concentrating a selected portion of the pulp, selection being made by screening, followed by hydraulic classification or not.

Screen Size	Per cent of Total Pulp	Kilos Silver	Per cent of Total Value
— 20	43.9	0.647	35.3
— 40	13.6	0.733	12.4
— 80	11.2	0.876	12.4
—150	6.6	0.859	7.0
—200	2.7	0.968	3.2
—200	22.0	1.086	29.1

A trial of the concentrates from the above samples showed that every particle of mineral liberated would easily pass a 60-mesh screen, but on account of the trouble and expense connected with fine wet screening it would be ore practicable to use coarser screens and handle a somewhat larger tonnage for the concentration. A Callow screen of 30-mesh slot-woven wire cloth, traveling at 60 feet per minute, gave the following results:

	Screen Size	Per cent of Total Pulp	Kilos Silver	Per cent of Total Value
Oversize.....	30	49.5	0.653	40.5
Undersize.....	30	50.5	0.945	59.5

The undersize from the above operation was classified into two grades of sand and one of slime, the latter being sent directly to the slime plant. By this scheme a very high grade of concentrate was obtained, and six tables were sufficient for a 300-ton plant. Conditions in the cyanide treatment were more normal, and the problem was solved successfully.

ASSAYING.

Notes on the Matte Assay.—Most assayers will be surprised to hear a method of fire assaying recommended which intentionally gives rise to the formation of a matte. Such, however, is the recommendation of Mr. L. J. WILMOTH, who communicates his method in the December *Journal* of the Chem. Met. and Mining Soc. of South Africa. He suggests its use for the assay of battery chips of iron and steel, and for copper drillings. He has even extended it to the assay of high-grade copper-bearing material with good results. The principal advantage derived from the formation of a matte is that it will take care of a large amount of base material.

The following charge was used with metallic copper: Drillings, 10 g; litharge, 1 AT.; sodium carbonate, 1.5 AT.; borax, 1 AT.; silica, 0.5 AT.; charcoal, 1.25 g; sulphur, 8 g; and a heavy iron nail. The average result from three assays was 10.417 per cent gold. The same sample assayed by the scorification method gave 10.31 per cent fine gold, and by the combination method, 10.49 per cent.

For copper matte carrying 25 per cent to 30 per cent copper and some lead the charge consisted of: Matte, 0.5 AT.; litharge, 1 AT.; sodium carbonate, 1 AT.; borax, 1 AT.; silica, 1 AT.; sulphur, 0.1 AT.; charcoal, 1.5 g; and a heavy iron nail. On pouring the charge the matte was easily detached from the lead button. On reassaying the matte it was found to contain no gold and only a little silver.

The author concludes that the application of the matte assay for copper-gold-bearing ores and products presents no difficulty and is of great advantage when the percentage of copper is high and the gold value low. The advantage is illustrated by the assay of 20 per cent copper matte. In this case a scorification gave 48.5 dwt. and a matte assay 53 dwt. per ton.

Recent Metallurgical Patents.

Iron and Steel.

Improved Construction.—With the object of providing a cheap, simple and efficient form of bosh, in which burning out is reduced to a minimum, Mr. FRANCIS J. ZIPPLER, of Avalon, Pa., has patented a form of construction shown in the accompanying cuts, Figs. 1 and 2. Fig. 1 shows the lower portion of a furnace embodying his form of invention, in which 1 represents

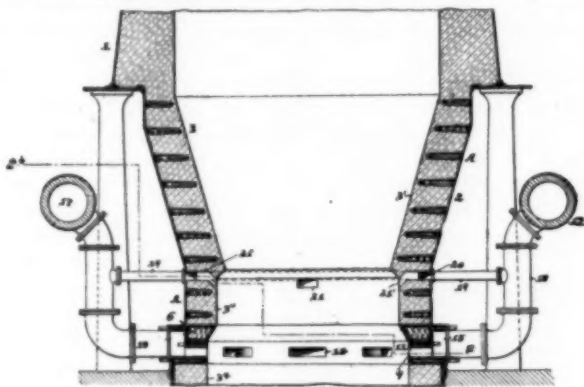


FIG. 1.—BOSH CONSTRUCTION.

the upper portion and 2 the bosh of a furnace. Fig. 2 represents a section along the line 2-2 of Fig. 1. The usual bustle pipe and tuyere supply pipes are designated by 17 and 18 respectively. Water jackets 6 and 9 form an annular air chamber 15, into which air from the pipes enters, being deflected into pockets 13 formed by the walls 12, so that it will pass around the same and into the tuyeres 14 of the furnace. At the same time a portion of the air blast will pass through the pipes 19, and thence into an annular space 20 in the wall portion 3, and enter the tuyeres 21. Owing to the tapering construction near the tuyeres, the lower or main blast is directed upward, and that from the auxiliary blast downward, through the charge. By the use of the annular air chambers, a large volume of air

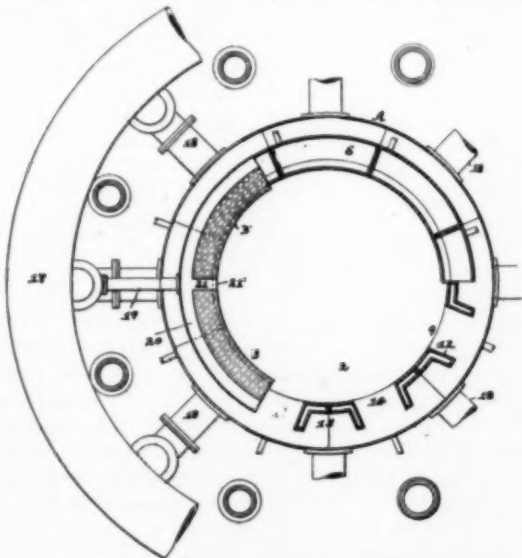


FIG. 2.—BOSH CONSTRUCTION.

is admitted and equalized before it passes through the tuyeres. By the use of the upper tuyeres in connection with the lower, the furnace is prevented from scaffolding, and will economize in fuel. The construction is further claimed to prevent the burning out of the bosh walls and the contained tuyeres. (986,792, Mar. 14, 1911.)

Conversion of Iron to Steel.—The type of apparatus in which iron is converted into steel by means of a surface blow is the subject of a patent granted to Mr. SELDEN S. DEEMER, of

New Castle, Del. In this process as heretofore practised there has been inefficiency by reason of the sluggish movement of the molten bath, and the difficulty of introducing means of desulphurizing, dephosphorizing, decarburizing or recarburizing the metal. The inventor's proposed converter and process are designed to overcome these objections.

Fig. 3 is a side elevation of the converter, and Fig. 4 a section on line 3-3 of Fig. 3. The converter has the usual outer shell and lining, with the bottom of the hearth rounded to present as little resistance as possible to the circulation of the metal during the blow. Air for the surface blow is provided by a suitable engine, and conducted to the tuyere B by way of the connection d', c and wind box C. The trunnion D is hollow and provided with a slotted opening d, through which the air may flow when the converter is in proper operating position. The tuyere may be a series of small openings or a single long one in the form of a narrow slot.

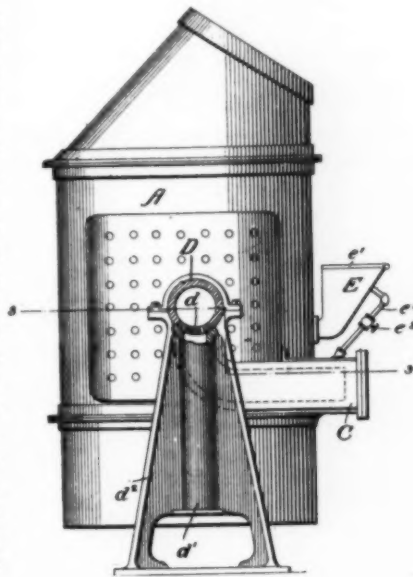


FIG. 3.—CONVERTER.

In order to provide for the suitable introduction of reagents at the proper time, a charging box E, divided by partitions and served by air from the main air chamber through pipes e', controlled by valves e'', is placed just above the wind box as shown in the cut. The opening from the charging box into the converter is arranged to deliver the reagents onto the molten bath at a greater oblique angle than that of the surface blow.

In operation the converter is charged with molten low-grade metal, such as pig iron, to the proper depth; the charging box is filled with the proper reagents; the air blast is turned on and the surface blow continues, with rapid circulation of the metal, until the time arrives for the charging of the reagents. This is accomplished by opening the proper valve e''. When the blow is completed the converter is tipped and discharged in the usual manner. (987,704, March 28, 1911.)

Agglomerating Fine Ore.—The preparation of fine and friable iron ores for smelting is the subject of an invention of Mr. HUGO DICKE, of Frankfort-on-the-Main, Germany, which he has assigned to Jacob E. Goldschmid, of the same place. The inventor claims that in previous devices

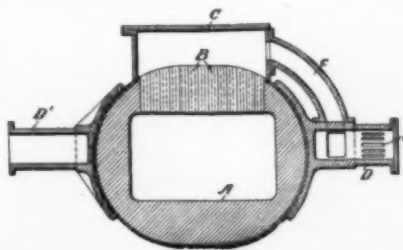


FIG. 4.—SECTION OF CONVERTER.

for agglomerating fine ore the principal fault has been the method of firing. He states that by firing a revolving furnace with water gas entirely new results are obtained in the treatment of iron ore. Not only can all the good results heretofore accomplished be obtained in the water-gas flame, but, owing to its peculiar formation, oxidation or reduction and fusion can take place at will. The essential advantage of the water-gas flame is the possibility of controlling it and adapting it to the needs of the material under treatment.

In the practice of the invention it has been ascertained that what is called a neutral water-gas flame, viz., one in which the proportions of gas and air are in chemical equivalents, iron ores of the formula Fe_2O_3 can be reduced to Fe_3O_4 , and that this will continue, even though the flame be slightly oxidizing.

The working of the furnace can be so regulated as to produce three zones of action; one in which drying and preliminary heating occur; another where oxidation and fusion are in progress, and a third where volatilization of noxious elements such as sulphur and arsenic may be removed. The inventor states that the furnace and water-gas flame may be used with equal advantage on ores of iron, copper, etc., the removal of small quantities of zinc, sulphur, arsenic, etc., being greatly facilitated in case of the latter. (986,271, March 7, 1911.)

Still another method of preparing fine materials for furnacing is that recently patented by Mr. GEORGE W. COGGESHALL, of Dedham, Mass. The process does not relate especially to iron ores, but is applicable to the preparation of mixtures of fine material preliminary to some subsequent operation in a furnace. The principal idea involved is to add a suitable binding agent, such as water or a solution of sugar, glue or the like, to an excess of the dry mixture, thus getting the full benefit of the binding agent without using an excess of it; then screening the unbound material from the nodules formed by the binder, and treating the nodules in any way desired. The operation can be carried on in an ordinary rotary drier, the upper part of which is screened to permit the discharge of the fine unbound material. The nodules pass over the screen to the lower part of the tube, which may be heated to bring about the desired reaction between the constituents of the nodules.

Specifically, the inventor applies his operation to the formation of potassium titanate, which is formed from dry, finely ground titanium oxide and anhydrous potassium carbonate. The mixture is subjected to the action of drops of water which agglomerate it into nodules, which are later heated to perfect the reaction. This takes place at a dull red heat and is almost quantitative in as short a time as 17 minutes. (987,554, March 21, 1911.)

A Blazing Tuyere has been devised by Mr. Charles A. Case, of New York, for the purpose of firing a furnace with liquid or gaseous fuel admitted through the tuyere with an air blast, and igniting the fuel electrically as it passes through the tuyere. The air jet passing through the tuyere has a tubular core of low-pressure air, surrounded by a zone of high-pressure air. The oil or gas used as fuel enters with the low-pressure air and passes an arc which ignites it. Combustion is supported by the low-pressure air core, while the high-pressure zone protects the shell of the tuyere from burning and supplies oxygen for the reduction of the ores in the furnace. (985,394, Feb. 28, 1911.)

Gold and Silver.

Treatment of Telluride Ores.—In view of the speculation which has been rife regarding the process used by the Portland Gold Mining Company at its mill at Victor, Col., the following patent specifications will be interesting. They form the basis of a patent granted to Mr. THOMAS B. CROWE, superintendent of the Victor mill and one of the staff engaged in experimental work prior to the adoption of the process now used. It is not to be inferred that the following is a statement of the process now being used at Victor, although it may contain some of the essential details.

The two main points in the patent are that an alkaline hypochlorite is a solvent for tellurium, and that, in order to apply this reaction profitably to telluride ores, it is necessary to remove from the ore all possible reducing agents, such as sulphides of the base metals. Another essential is that the natural acidity of the ore be *just* neutralized, instead of having an excess of lime, for example, as is customary in ordinary cyanidation.

The inventor mentions the use of an alkaline persulphate with potassium cyanide for the similar purpose of dissolving tellurium and gold in telluride ores, but states that he has found the required quantities so large as to be economically prohibitive. He further states, however, that he has discovered that cyanogen iodide will serve as a suitable and efficient solvent if the natural acidity of the ores is just neutralized as stated above. The advantage in the use of cyanogen iodide is that it is at once a solvent for both gold and tellurium thus being a simpler reagent than a combination of, say, potassium cyanide and an alkaline persulphate. The claims granted in the patent, however, refer only to the use of an alkaline hypochlorite and alkaline cyanide, and not to the use of cyanogen iodide. The removal of sulphides by concentration and the neutral state of the ore are referred to as necessary conditions. (987,964, March 28, 1911.)

Vacuum Filters.—A continuous vacuum filter has been devised by Mr. GEORGE JOHNSTON, of Chihuahua, Mexico. As to its type, it consists of a number of filtering frames of

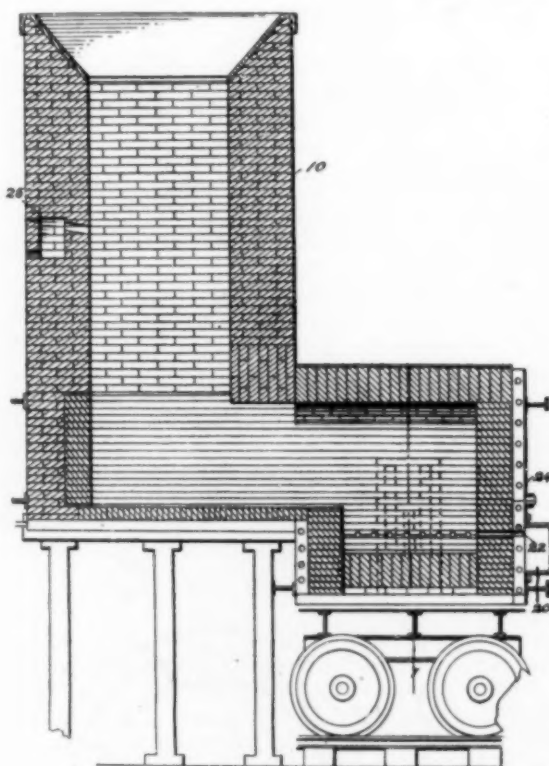


FIG. 5—VACUUM FILTER.

the usual construction arranged singly or in groups around an axis. The axis and frame are made to revolve so that the filter frames are successively immersed in the pulp to be filtered and raised out of the pulp for the purpose of washing and discharging the cake. The filter is in reality a modification of the drum filter idea, in which the filter surface is made of a number of frames, instead of the periphery of a drum. Or, in other words, it is a modification of the ordinary leaf filter idea, in which the leaves are subjected to continuous instead of intermittent operation.

The apparatus is arranged in such a manner that when the filter leaves are immersed in solution they are also in connection, through suitable valves, with a vacuum pump, and that as they revolve out of the solution they are brought to a position convenient for washing and dumping the cake. If used for the filtration of gold cyanide solutions it would appear that the filter is not complete in itself for there is no provision for displacing the solution held in the pulp, and this operation would have to be performed in a second filter treating the discharged cake from the first. (988,107, March 28.)

Copper.

Continuous Matte Smelter.—A novel idea in copper smelting furnaces has been patented by Messrs. REDICK R. MOORE, of Garfield, and JOHN H. KEES, of Salt Lake City, Utah. The furnace has for its object the continuous production of a matte of lead, copper, nickel, cobalt and the precious metals, without the need of previous roasting and without the addition of carbonaceous fuel.

As shown in Fig. 5, the furnace consists of a stack 10 and a converting chamber 14 connected by a passage 13. The converting chamber is suitably mounted on wheels to facilitate its removal for repairs, etc.

The underlying object is to utilize the heat escaping from the converting chamber to smelt the ores in the stack, causing them to melt and run into the converting chamber, where they are converted into a matte by a suitable blast applied through tuyeres 22. The air blast is supplied through a flue 20 surrounding the converter. The latter is water jacketed in the usual manner, shown conventionally at 24.

In operation the stack 10 is charged with the ores to be reduced, and a quantity of molten matte from any source is placed in the converter. Vapor of S and SO₂ are both present with nitrogen in the upper part of the furnaces treating pyritic ores and the sulphur will condense on the cool charge if it be high enough above the source of heat. As the charge continually travels downward the condensed sulphur will be again vaporized, resulting in a zone where the charge is permeated with sulphur vapor. This may be removed by a condensing arrangement, 25, which is a pocket opening in the stack wall.

When the air blast is turned on heated air will be forced through the matte, oxidizing iron, sulphur, etc., forming ferrous sulphide which will unite with the silica and other constituents of the charge in the stack to form a molten slag and produce sulphurous gas which with the nitrogen of the air will give up its heat to the cooler charge in the stack (thus melting down more sulphide to be converted into matte in the lower chamber, and supply fuel for further smelting. (985,195, Feb. 28.)

Treatment of Low-Grade Ores.—The recovery of copper from the so-called porphyry copper ores of the West is usually accomplished by concentration and smelting. The ores contain an average of 2 per cent copper and they are treated on a huge scale. Mr. GEORG SCHNEIDER, of Lauenstein, Germany, proposes a chemical method of treatment which he believes would result in greater percentage recovery of copper.

His experiments have shown him that such ores are amenable to treatment consisting of a roast with 10 per cent salt at a low red heat, and subsequent lixiviation with 5 per cent HCl solution for eight hours. His tests showed that ore containing 2.34 per cent copper would yield 2.22 per cent metal. He finds that these results are due to the presence of silica in the ore, which acts in a way to decompose the alkaline chloride used, liberating chlorine for the chlorination of the copper sulphides. It is claimed that this process would be cheaper and more efficient than the present method of concentrating and smelting, and that ores of as low a grade as 1 per cent copper could be treated at a profit. Any silver in the ore would be extracted as chloride in the presence of iron and alkali chlorides and gold would have to be extracted by the ordinary chlorination process. (986,508, March 14, 1911.)

Nickel.

Sulphide ores of nickel, cobalt, iron, copper, arsenic, zinc and molybdenum, but particularly nickel, may be treated according to a process recently patented by Mr. JAMES A. McLARTY, of Toronto, Canada. His object is to oxidize the sulphide ore without resorting to the usual roasting process. Preferably he first concentrates the ore in the usual manner, after which it is treated in a magnetic concentrator to remove iron and nickel sulphides. These are then oxidized by heating in a closed vessel with steam at 125 lb. pressure. The reaction which follows forms oxides of the metals and H₂S gas. The nickel oxide thus formed is not magnetic and may be re-

moved from the iron oxide which is magnetic by again passing the pulp through a magnetic separator. (987,156, March 21, 1911.)

Centrifuge Tester.

In our March issue, page 147, a machine for the separation of liquids and solids by centrifugal force was described, which has recently been developed by the De Laval Separator Company, 165 Broadway, New York City. In this development work, which extended over ten years, the engineers of this company had to carry out a large number of tests with mixtures of materials of all kinds to see what kind of a separation could be made with them by centrifugal force.

For these tests they developed a small centrifuge tester, which has proven exceedingly convenient and handy for such work. It is operated by direct steam, the steam acting on a turbine wheel mounted on a flexible shaft, and the driving mechanism being very similar to that of the well-known De Laval cream separator. On the basis of many years' practical experience with the latter it has been possible to give to the



CENTRIFUGE TESTER.

small centrifuge tester a very rigid and compact construction.

When the tester revolves the test tube pockets take a horizontal position, as is indicated by a dotted line for the right-hand pocket in the adjoining illustration. There is, of course, nothing new about this. But the feature of the De Laval tester is the exceedingly high speed which can be obtained without difficulty and the wide speed-limits within which it can be operated. This tester can be driven up to a speed of 4000 revolutions per minute, which is believed to be much higher than the maximum speed obtained in former machines of this kind. In this way a pressure of 168 pounds per square inch can be obtained for water, the corresponding pressures for other materials being easily determinable from this figure with the aid of their specific gravities.

As the speed can be lowered down to about 100 revolutions per minute, it is evident that any suitable pressure within wide limits can be obtained and that with this tester it is easy to determine quickly the possibilities of separation by centrifugal force in any given case.

A New Type of Synchroscope.

In the alternating-current power plants, which are now the rule rather than the exception in our large metallurgical and chemical works, the parallel connection of alternators is still at times a troublesome problem. At present there are only two types of synchronizing device in general use, namely, the synchronizing lamp or voltmeter and the rotating synchroscope. The first method is crude and consumes much time. It is en-



FIG. 1.—FRONT VIEW OF SYNCHROSCOPE.



FIG. 2.—PHANTOM VIEW SHOWING LAMP AND POINTER.

tirely unsuited to use on large systems. The second device is unreliable and is generally used with synchronizing lamps to guard against a fatal error. At best the rotating synchroscope, even when combined with a lamp, is an extremely unsatisfactory device, since it requires the operator to divide his attention between the lamps and the instrument.

There has recently been placed on the market an entirely new type of synchroscope, which has all the characteristics of an ideal rotating synchroscope and at the same time its indications are infallible and accurate.

In construction the instrument is quite similar to the new Weston type switchboard single-phase wattmeter; that is, it is a Weston electro-dynamometer instrument. The pointer is mounted behind a translucent glass and stands normally in the middle of the scale. Behind the pointer is installed a small synchronizing lamp, which casts the shadow of the pointer on the scale. The pointer is only visible by the light from this lamp.

The connections of the instrument are shown in Fig. 3. The movable coil is connected in series with a condenser across the incoming machine, while the fixed coil is connected in series with a slightly inductive resistor across the line. The lamp is connected in the secondary circuit of a special three-legged transformer with two primaries, one across each source. The lamp transformer, condenser and resistor are mounted on one base and installed in an auxiliary box.

The mode of operation may be easily comprehended by thinking of the instrument first as a correctly designed wattmeter. It is well known that a good wattmeter will show no deflection when the current and e.m.f. are in exact time quadrature; therefore, in the present instance, if the constants of the circuits are properly chosen the currents in the coils will be in quadrature when the e.m.f.s. of the two sources are in phase coincidence or in phase opposition. That is, the pointer stands at rest in the middle of the scale under these conditions, and since the lamp is dark when the e.m.f.s. are in phase opposition, it will be seen in this position only when the machines to be

synchronized are in exact phase coincidence with each other.

For every value of phase displacement between the e.m.f.s. a corresponding torque will be developed and the pointer will be deflected to one side or the other, depending upon whether one of the waves is lagging or leading with respect to the other. That is, a good wattmeter connected in this way will indicate the phase displacement between two e.m.f.s.

When the frequencies of the two e.m.f.s. differ, the phase displacement between the two will vary continuously through complete cycles of 360 time degrees and the currents in the coils of the instrument will alternately lag and lead with respect to each other, and the pointer will swing back and forth over the scale.

Such an instrument would indicate a difference in frequency, but would give no information as to which one of the machines is fast or slow. Here is where the lamp comes in. One complete swing corresponds to a phase displacement from quadrature plus or minus to quadrature minus or plus, and this period also coincides with the period of incandescence or darkness in the lamp; therefore, the pointer will be seen only during every other swing, and will appear to rotate smoothly and silently in one direction. The direction of apparent rotation indicates whether the incoming machine is fast or slow and the speed of rotation is a measure of the amount by which the frequencies differ.

Just what takes place inside the instrument is best demonstrated by a diagram such as Fig. 4. At the top of the diagram are shown two waves, which differ in frequency. These two waves may be chosen to represent the currents in the primaries of the lamp transformer, then the resultant (shown dotted) may be considered as the current active in the lamp. Assuming that when the resultant current remains inside the shaded band the lamp filament will not be incandescent, the period of light and darkness is roughly determined by considering the points where the current crosses the band as transition points

tion of apparent rotation indicates whether the incoming machine is fast or slow and the speed of rotation is a measure of the amount by which the frequencies differ.

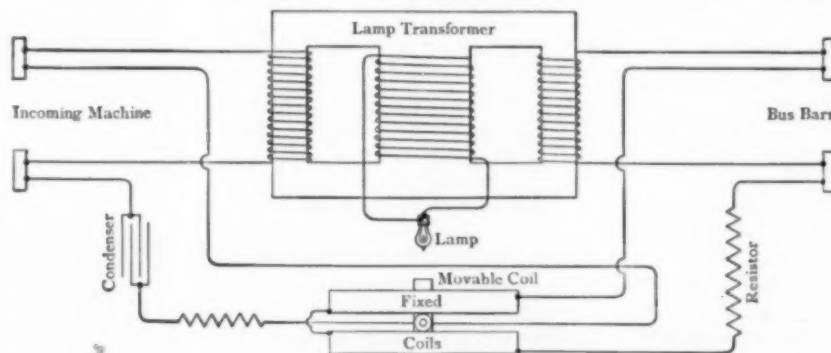


FIG. 3.—CIRCUIT DIAGRAM.

between light and darkness, which may be found from diagram.

Assuming the fast wave to belong to the incoming machine, the currents in the coils of the instrument may be represented by plotting the slow wave exactly as it is shown at the top and plotting the fast wave 90 time degrees ahead of its original position to allow for the effect of the condenser. This has been done in the middle set of waves. The product of these current waves gives the torque active in the instrument, which is shown by the curve bounding the shaded areas. The sloping straight lines indicate the general trend of the average torque. They show that when the incoming machine is fast the pointer travels from left to right during the time the lamp is lighted.

The bottom set of waves is constructed in the same way as the middle set and shows that when the incoming machine is slow the pointer reverses the direction of apparent rotation.

The accuracy of this instrument is quite remarkable, es-

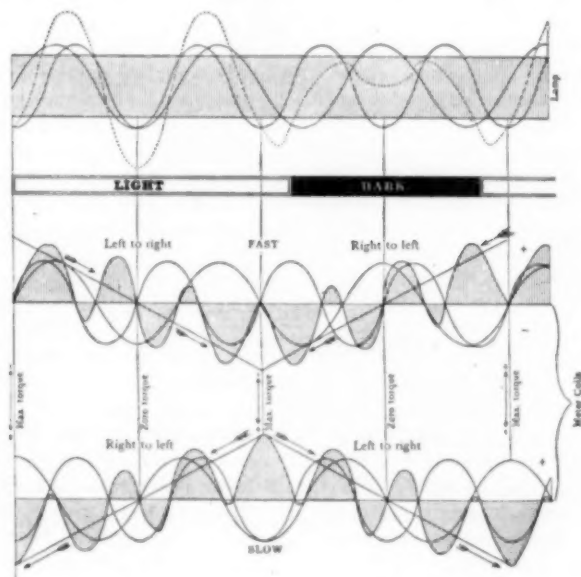


FIG. 4.—PERFORMANCE DIAGRAM.

pecially as regards its freedom from errors due to fluctuations in voltage or frequency. For example a 60-cycle, 110-volt synchroscope, when subjected to frequencies varying from 40 to 80 cycles per second and e.m.fs. varying from 95 to 130 volts, indicated true synchronism to within 1 deg. of phase coinci-

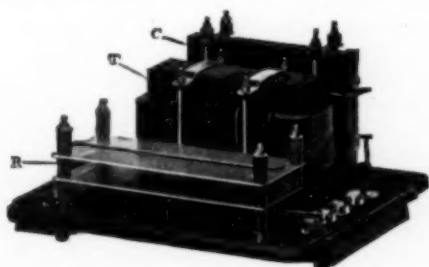


FIG. 5.—AUXILIARY DEVICE.

dence. This new type of synchroscope has been placed on the market by the Weston Electrical Instrument Company, of Newark, N. J.

The application of these principles to the operation of a synchronizing device is the invention of Mr. B. P. Romaine.

Personal

Mr. Lucien I. Blake, consulting engineer of the Submarine Signal Co., Boston, and inventor of the Blake machine for electrostatic separation of ores, intends to spend the coming year in Europe, traveling in the interests of the Submarine Signal Company and to inspect various ore treatment plants. Mr. Blake has made his home in Denver for the past few years, where certain problems in ore dressing have attracted his attention.

Mr. Warren F. Bleecker, of Denver, is spending some weeks in New York preparing for the erection of a mill in the San Juan district of Colorado, for the treatment of vanadium ores.

Mr. D. W. Brunton has returned to Denver after spending a few weeks at Hot Springs, Ark., where he was obliged to go for his health.

Prof. Bucherer, of Germany, during his recent brief stay in this country, attended the smoker at the New York meeting of the American Electrochemical Society. While he is now professor of theoretical physics at the University of Bonn and, by fundamental experiments, has largely contributed to the modern theory of relativity, Professor Bucherer was years ago among the pioneers of industrial electrochemistry, being connected for a year with Mr. Alfred H. Cowles in his early electrochemical development work.

Mr. J. J. Fitzgerald, of Florence, Colo., is acting as mill superintendent for the Frontenac Consolidated Mines, Ltd., at Black Hawk, Colo.

Mr. Mark R. Lamb, who recently returned from a South American trip, has been appointed manager of the South American branch of the Allis-Chalmers Company, with offices in Santiago, Chili.

Mr. Victor G. Hills, of Denver, has been appointed consulting engineer of the Scheelite Mines, Ltd., in Nova Scotia.

Mr. Frank Klepetko has been in Peru making an examination of the Ferrobamba copper property.

Dr. Karl Georg Frank, the American representative of the Siemens & Halske Company, has sailed for Germany and is expected back in about two months.

Chief Engineer Maleyka, **Mr. Werner von Siemens**, and **Dr. Puppe**, all of the Siemens & Halske Company, of Germany, are in this country to study American practice in the use of electric power in large metallurgical plants, especially electric driving of rolling mills.

Prof. Robert H. Richards will spend some time in the West this spring, visiting Montana and other Western States.

Mr. Jesse Scobey has acquired an interest in the ore-testing plant of Henry E. Wood, Denver, and will be in charge of the works in the future. Mr. Scobey's superintendence of this work will insure fair and accurate tests on ore sent to the plant.

Mr. George F. Waddell, mill superintendent of the Nevada Consolidated Copper Company, McGill, Nev., is making a professional trip among the Western copper concentrators to inspect the methods of slime treatment, with a view to making some improvements at McGill.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ORE TREATMENT (Continued).

317,246, May 5, 1885, to Edward P. Thompson, of Elizabeth, N. J., and E. P. Roberts and G. H. Pierce, of Cheyenne, Wyo., assignees.

Gold. Electro-deposits from a solution of its chloride. The cell is a circular vessel, containing concentric annular cathodes of corrugated sheet copper. Between them is an anode consisting of depending electric-light carbons arranged in a circle. Steam is admitted to the electrolyte, heating and agitating it. The gold-plated cathodes are then removed to another cell containing a solution of sulphuric acid or copper sulphate and a current is passed from them to an intermediate cathode of copper. The copper of the former cathodes, now anodes, is thus dissolved and redeposited, leaving the gold.

332,705, Dec. 22, 1885, to Henry H. Eames, of Philadelphia, Pa.

Gold, silver, etc. Electrolytically chlorinates prior to amalgamation or lixiviation. The cell is a cylindrical iron vessel

lined with wood and having a steam-tight iron cover with man-hole, safety valve and gage. The electrodes are opposed copper plates, secured to the inside of the tank and extending from top to bottom. A shaft passes up through the bottom of the cell, carrying a water-sealed depending cone with vertical stirrers. The electrolyte is a solution of sodium chloride, sulphuric acid, or iron or copper sulphate, into which the pulverized ore is charged. Steam is used at a pressure of from 20 lb. to 25 lb.

333,815, Jan. 5, 1886, to Michel Body, of Liege, Belgium.

Gold, silver, copper, nickel cobalt. The ore is subjected to preliminary treatment by exposing a heap of it wetted, to the atmosphere. Spent electrolytic liquor is preferably used for wetting. Or a sodium chloride solution, or calcium or magnesium chloride lyes, may be used. Or the pulverized ore can be roasted. The ore is then electrolytically dissolved at the anode of a cell containing a solution of a ferric salt and sodium chloride. The ores are thus dissolved by the action of the ferric salts, simultaneously converted into ferrous salts; the dissolved metal is deposited at the cathode, and the evolved chlorine re-oxidizes the ferrous salts, any excess assisting in dissolving the ores. The electrolytic cell is a rectangular vessel of Portland cement, painted inside and out with an impermeable coating. The inner portion of this floor is elevated and supports a carbon-plate anode. The four sides of the vessel are lined with carbon. A central compartment is provided by vertical inner walls, between the lower ends of which and the elevated portion of the floor are diaphragms of felt. The ore is placed in this central compartment, which contains a revolving stirrer, resting on the carbon anode, and the inner and outer compartments are filled with a solution preferably consisting of water, 100 parts; sodium chloride, 20; iron persulphate, 5; and sulphuric acid, 5. The solution is introduced into the central compartment and flows upward and over its walls into the four outer compartments, escaping from their bottoms. The metal is precipitated on copper cathodes, depending into the outer compartments.

BOOK REVIEWS.

Engineering Chemistry.—A manual of Quantitative Chemical Analysis for the Use of Students, Chemists and Engineers. By **Thomas B. Stillman**, M.Sc., Ph.D. Late Professor of Engineering Chemistry in the Stevens Institute of Technology. Fourth edition; 8vo, 744 pages, 174 illustrations, price \$5.00. Easton, Pa.: Chemical Publishing Company.

The excellences of this work are well known to all students of chemistry. This edition has been brought up to date in all departments. The chapters on coal, alloys, lubricating oils, and paints have been amplified by the addition of specifications for the purchase of these materials. The subject of pyrometry has been revised by Messrs. E. A. Uehling and W. H. Bristol. A chapter on "Foundry Chemistry" has been contributed by H. E. Fields, one on "Official Methods of Sampling Iron Ore" by Chief Chemist J. M. Camp, of the U. S. Steel Corporation, and one on "Acetylene" by R. E. Brückner. The new edition is, therefore, a considerable improvement on the valuable and much appreciated earlier edition, and will prove an acceptable addition to chemical engineering literature.

Iron and Steel: A pocket encyclopedia, including allied industries and sciences. By **Hugh P. Tiemann**, B.S., A.M. 354 pages, 43 illus. Price, \$3 net. New York: McGraw-Hill Book Company.

This little book is a combination of a dictionary, a cyclopedia and a handbook. It is alphabetically arranged, giving under each heading a concise definition and description (sometimes illustrated) of the apparatus or process in question. Cross references are numerous. With respect to the subject matter included the book is absolutely up to date.

That there should be a large demand for such a book is admirably brought out in an introduction written by Prof. Henry M. Howe, of Columbia University, from which we quote the following:

"The jargon of the millman, like that of the philosopher, is a deplorable necessity. It is a collection of invaluable special tools for special men doing certain work. When the dentist and the obstetrician regard the unfathomable mysteries of each other's 'kits,' each has the consolation that he need not attempt the fathoming. But, alas, you and I cannot thus escape each other's jargon, for the metallographist must needs learn from the millman and the millman from the metallographist, and each has become the slave of his own tools, his own jargon. He talks and perhaps thinks in terms of it, if indeed we think in any language, which I doubt. At least, if he thinks in any language it is in his jargon. Life is too short, patience too flimsy, to permit our forcing our thoughts into others' minds by means of any tools other than our own jargon. The author gives me an admirable case in point.

"Foreman: 'How does this steel work?'

"Heater: 'If you don't wash it, it won't clean.'

"This is 'shorthand' for: 'The iron oxide or scale which forms on the surface of this steel adheres so firmly that, unless it is heated so highly that it melts, some of it will cleave to the metal during the operation of rolling and hence will deface the finished plates into which the steel is to be rolled.' The heater's words are not English; they are jargon, and it is proper that they should be. If he persisted in translating them into English as I have done, and in talking English in general, he would simply justify the dismissal which would surely come. The guild has evolved its jargon for its own use. To replace it with the king's English would be as unwise as to replace it with French or modern Greek, or to replace 'shorthand' with 'longhand' in the reporting of debate.

"When the metallographist and millman meet it is as the meeting of French and Greek. The millman scolds the metallographist; yes, and I have had to endure with my scanty patience many such scoldings for deliberately inventing jargon, useful for the metallographic guild, but a stumbling block to the millman. Of course, it is not I, but the nature of things that ought to be scolded; but then it is pleasanter and less transparently foolish to scold me, especially if I have previously earned your gratitude by 'disentangling some of your fallacies and sophisms.'

"Now, here comes the gallant author to the aid of fumbling metallographist and irritated millman. With infinite pains, ingenuity and skill he blesses both where they had banned each other, and enables the brothers to dwell together in harmony, unfurling to each the jargon of the other by means of a tri-lingual dictionary, translating the jargons of both into the common language, English."

The book has even a wider scope. While it forms, as Professor Howe points out, an admirable connecting link between millman and metallographist in the steel industry, it should appeal with equal force to the large number of chemists, electrochemists, mechanical engineers and others who, while not primarily active in the iron and steel field, are necessarily interested in its development and are often puzzled by the jargons of the steel millman or metallographist, however familiar may be the conceptions expressed under other names. In all such cases this little book will prove an easy and effective key.

If a suggestion may be made for future editions—which should surely be numerous—it is the addition of references to existing literature; not a complete bibliography, but in each case a reference to one or two of the principal publications on the subject. The increase in volume would hardly be prohibitive, while such references would often be very handy, even for the experienced steel man. As it is, this little volume is certainly excellent.